Developing Synoptic Human Threat Indices for Assessing the Ecological Integrity of Freshwater Ecosystems

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Project Funded by US EPA Region 7
Wetland Program Development Grant
and Missouri DNR 319 Grant

Missouri Department of Natural Resources

Meeting Overview

- Project overview
- Progress since last meeting
- Introduce Preliminary Human Threat Index
- Threat Index Discussion

Project Overview Outline

- Background
- Goal
- Data & Methods
- Creating “Threat Index”
- Resulting Products
- Utility

Funding Sources

- Iowa, Kansas, and Nebraska portion
  - EPA Wetlands Development Grant
- Missouri portion
  - U.S. Environmental Protection Agency Region VII, through the Missouri Department of Natural Resources, has provided partial funding for this project Under Section 319 of the Clean Water Act

Background / Key Issues

- Resource managers don’t necessarily manage the resource, but manage human activities that impact resource quality
- Common questions of resource managers:
  - What factors threaten the ecological integrity of a stream of interest?
  - What threat is most pervasive?
  - Where are these threats within the network or watershed?
- Answering these questions helps us target specific threats at specific locations

Potential Human Threats

Land Use

Impervious

Railroads

Channelized Streams

Airports

Toxic Releases

Superfund

Oil and Gas Wells

Mines

Landfills

Hazardous Waste Sites

Waste Water Treatment

Leaking Underground Tanks

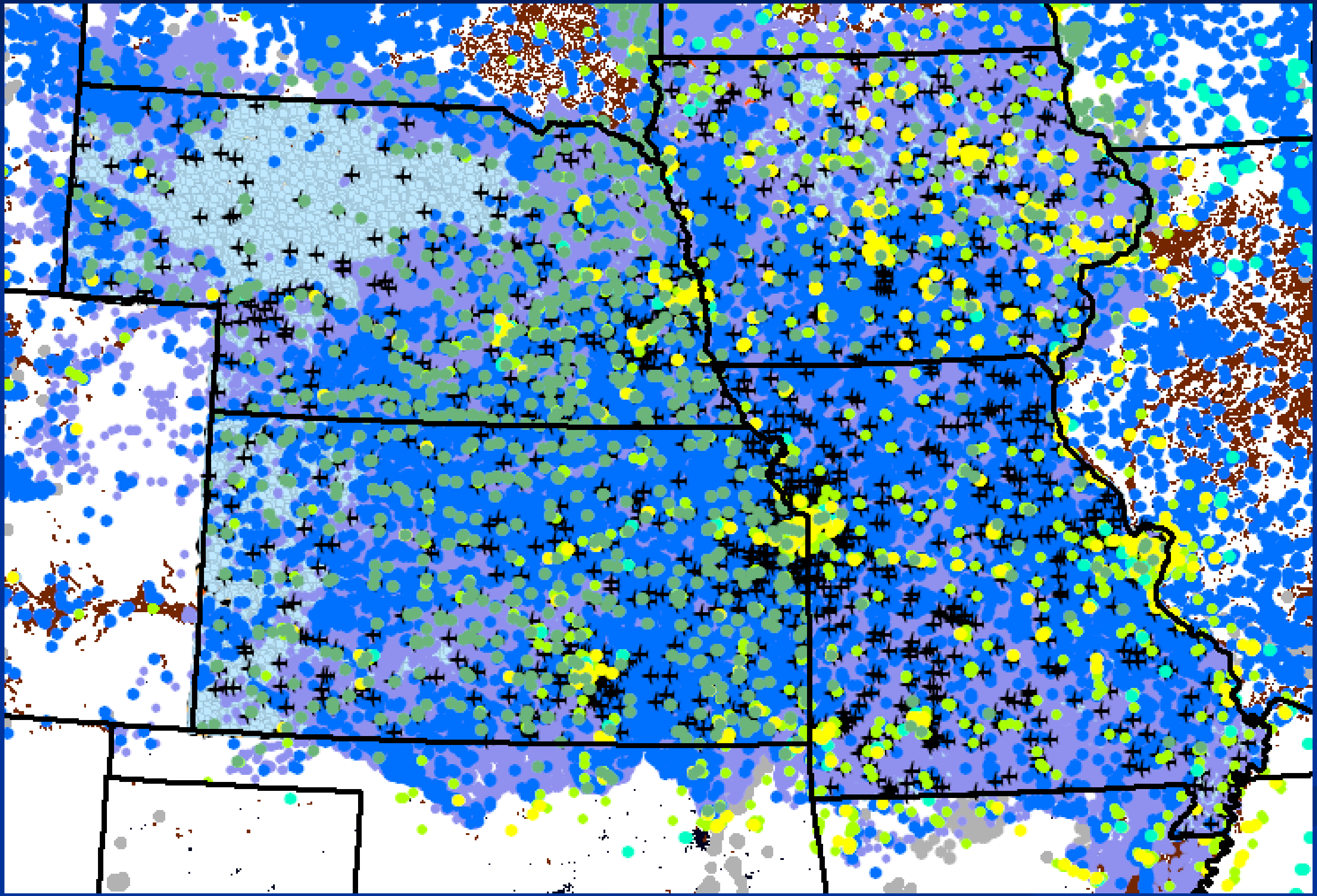
CAFOs

Dams

Roads

Headwater Impoundments

Certified Wells



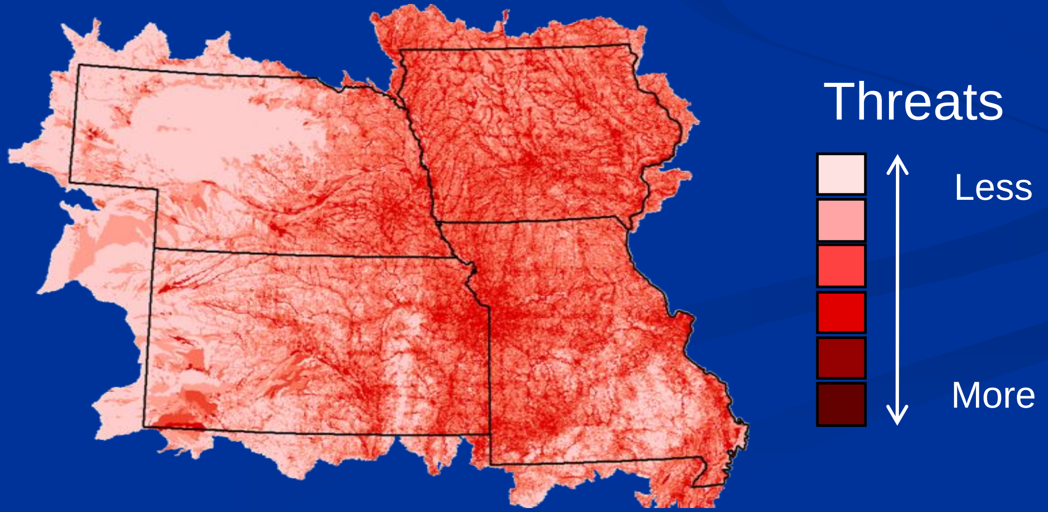
What we are trying to accomplish?

Goal:

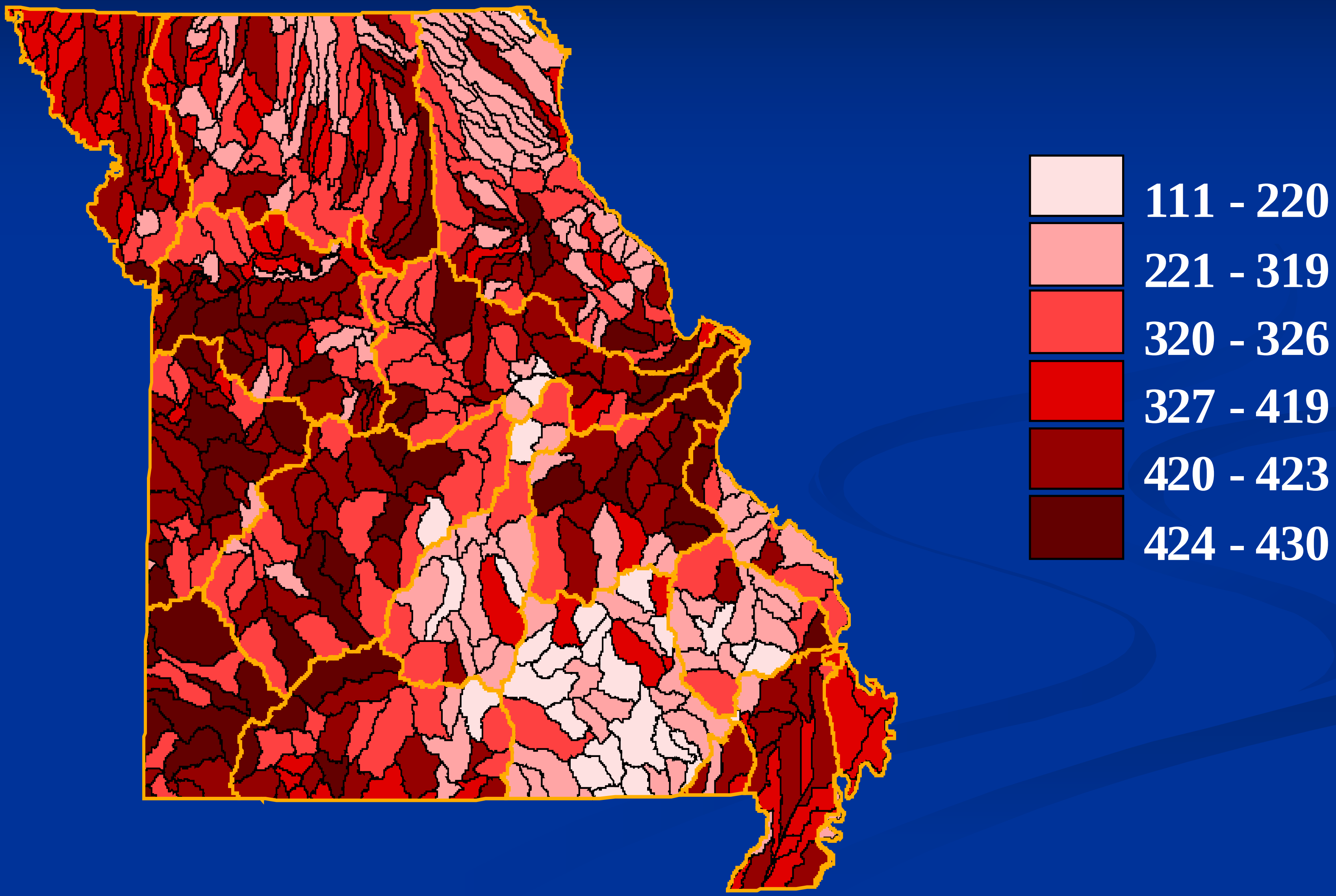
Develop reach scale GIS-based Synoptic Human Threat Indices (HTI) for assessing ecological integrity of freshwater ecosystems

EPA Region 7

Iowa, Kansas, Missouri, Nebraska



Missouri Example: Human Threat Index (HTI)



Limitations with Missouri HTI

- Large assessment unit
  - 237 Sq. Km average
- Does not account for contributing area outside of individual sub-watershed polygon
  - Local polygon only
- Limited number of “threat” datasets as input
  - Eleven

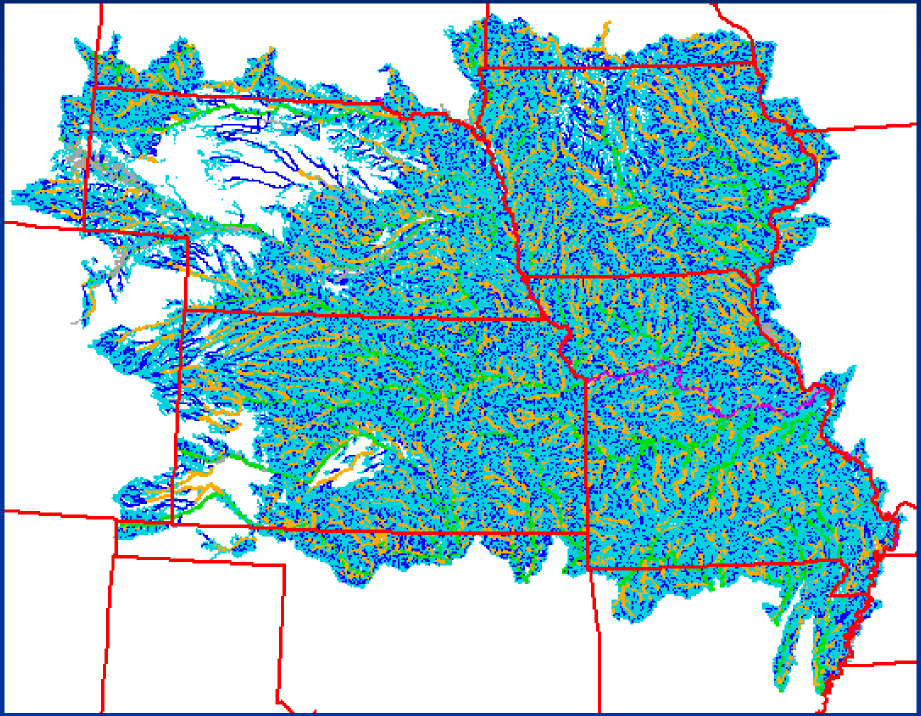
EPA Region 7 Primary Objectives:

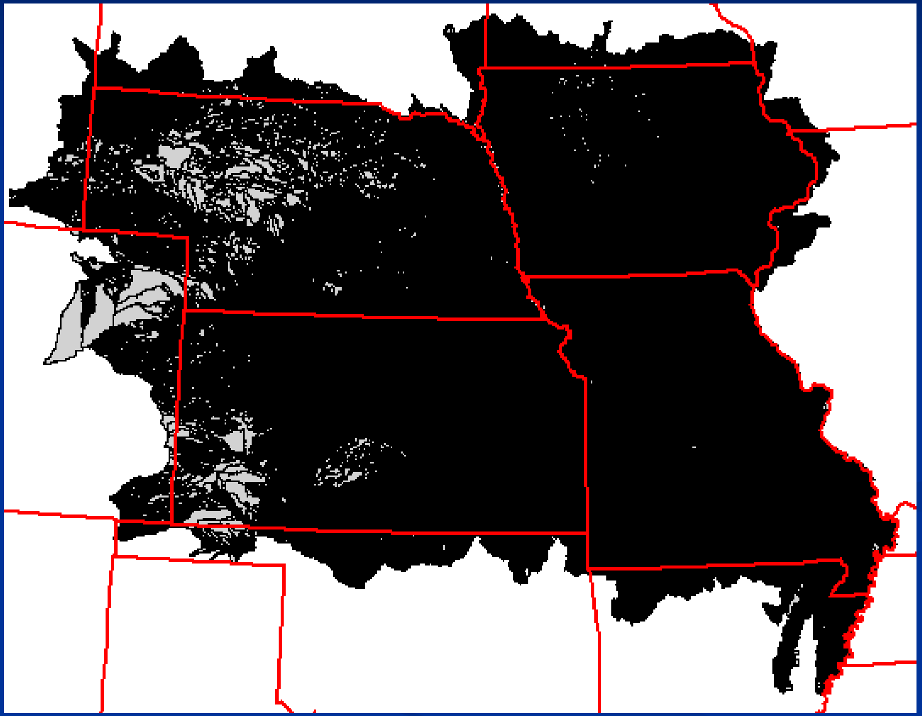
- Create a "threat assessment tool" useful for on the ground management
  - Fine resolution
- Utilize as many threat datasets as possible
- Consider the drainage area above <u>each</u> stream segment
- Consider riparian condition
- Account for distance
- Useful for five components of ecological integrity

Methods

- Establish a Regional Oversight Committee
  - "Experts" from each state
- Conduct Literature Review
- Create assessment units
- Gather "threat" datasets
- Quantify "threats"
  - Local
  - Watershed
  - Riparian
- Rank and create Threat Index

Assessment Units



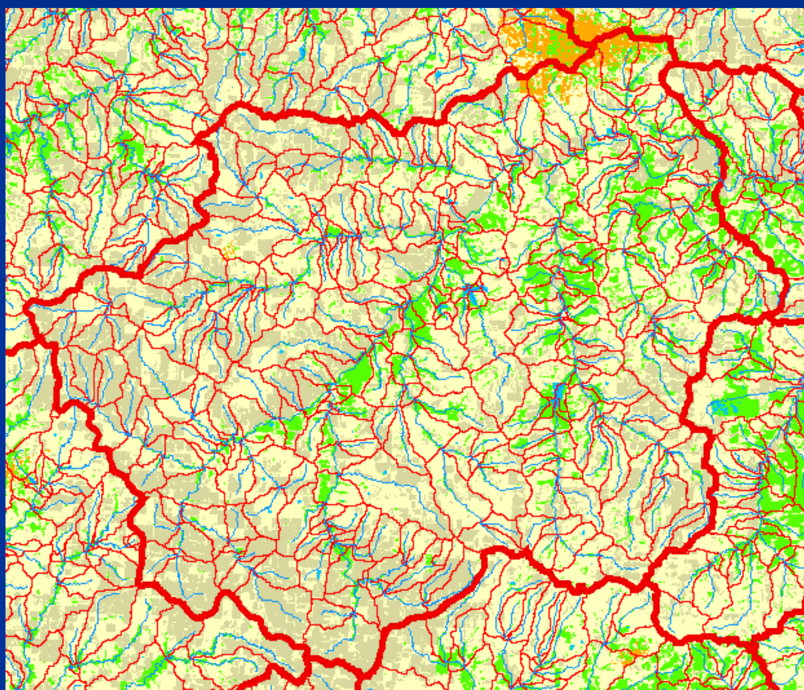


385,000 primary channel stream segments ⟶ corresponding catchment polygons

And Stream Buffers (riparian condition)

Small Assessment Units

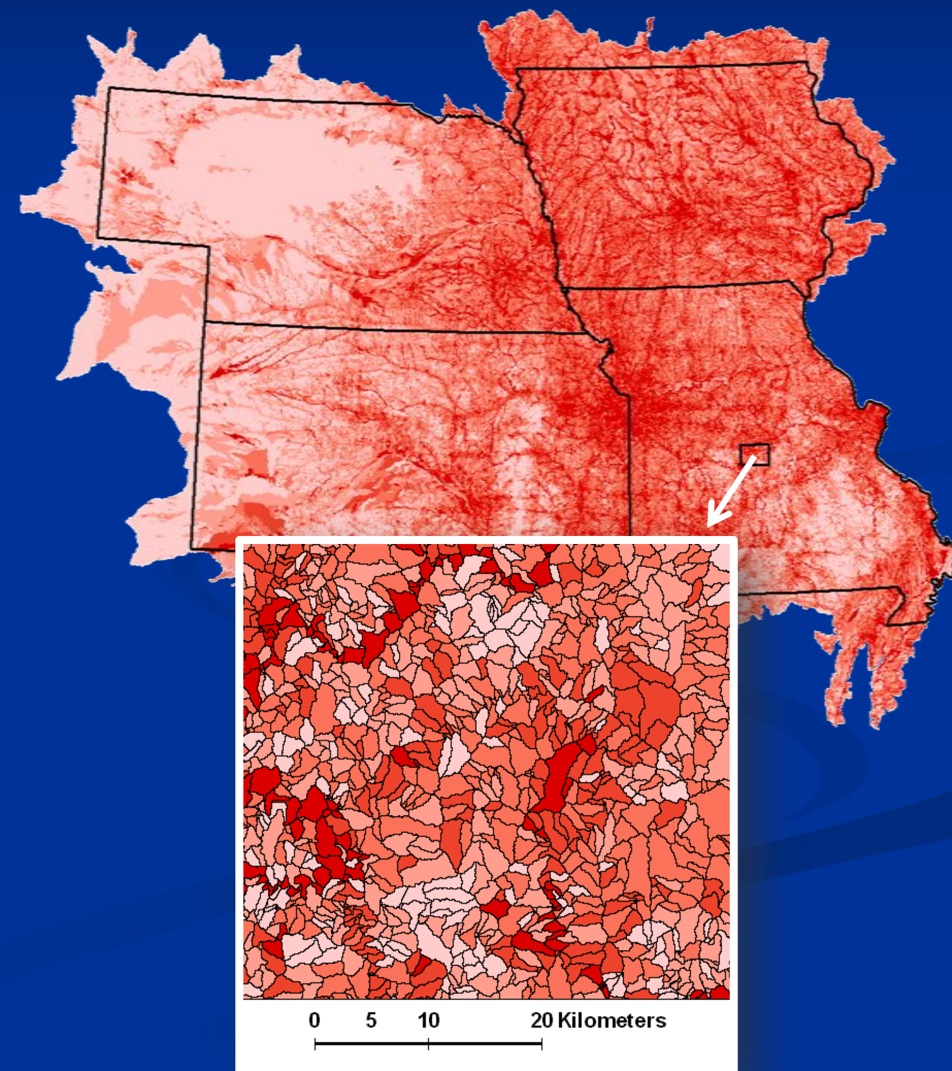
Assessment Units



Streams

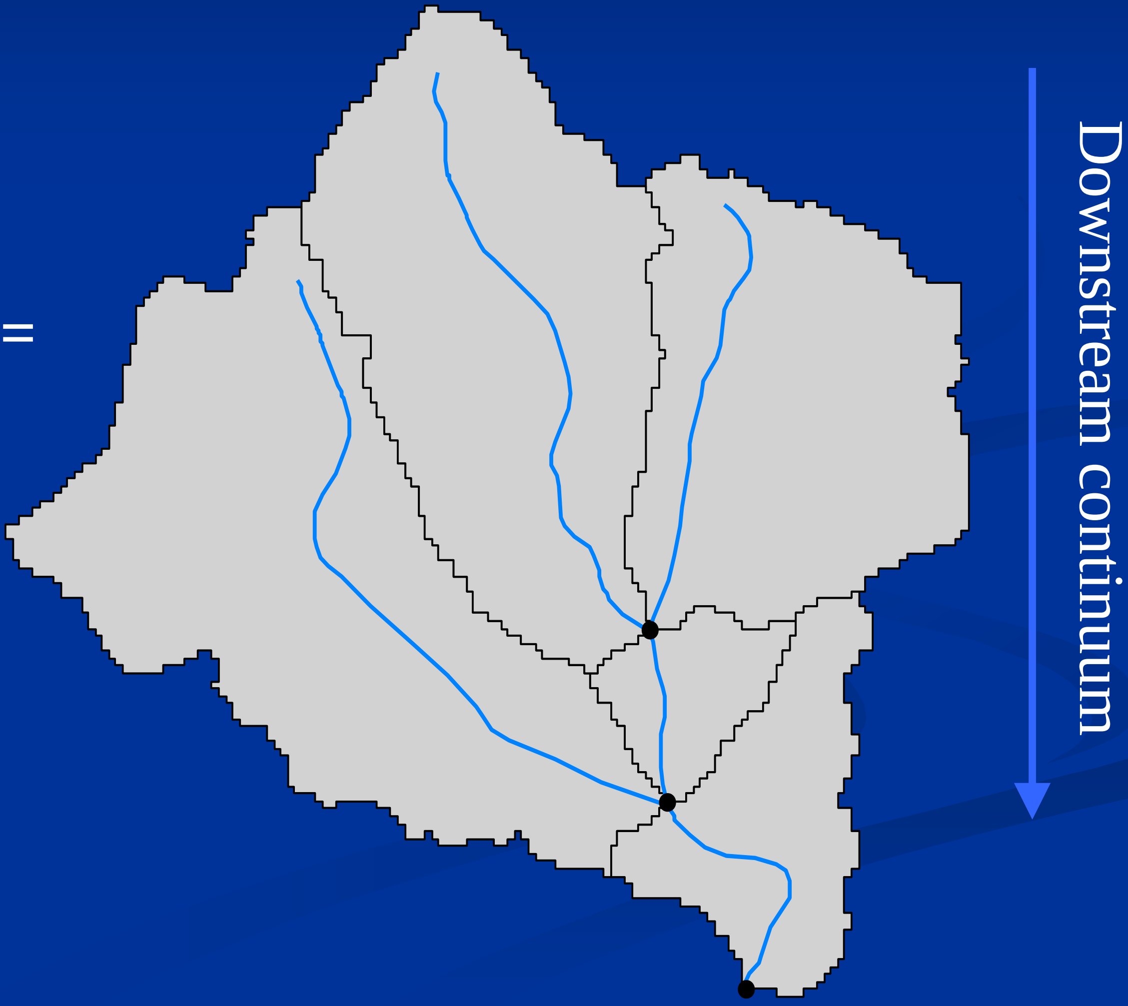
Assessment Polygon

Urban	Forest and Woodland
Row and Close Grown Crop	Swamp and Marsh
Grassland	Open Water



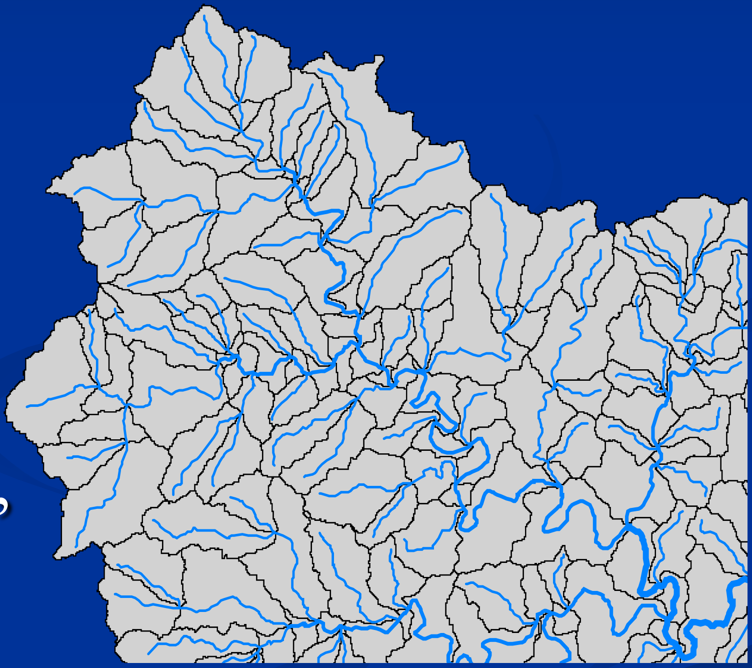
Watersheds / Catchments/ Segment sheds / Reach Specific Drainage Areas

DEM + Stream Network =



Stream Segments Linked to Catchments

- 1 to 1 relationship
  - Stream segments & polygons
- Watershed properties can be accumulated downstream
  - Total drainage area, point sources, length of road, land cover, etc.
  - Can be converted to a proportion of the drainage area or stream miles



Gathering Threat Data

- Brainstorming with Regional Oversight Committee
- Data search
- More challenging that expected
  - Must be consistent over 4 state area
- Data issues
  - Completeness
  - Multiple sources of the "same" data
  - Location

Threat Datasets

Agriculture:
Cropland
Pasture/rangeland
Row crop chemicals
Pasture chemicals
CAFO

Stream alteration:
Dams
Major reservoirs
Headwater impoundments
Channelization
Distance to reservoir
Fragmentation

Transportation:
Airports
Length of road
Road – stream crossings
Length of Railroads
Rail – stream crossings

Human infrastructure:
Population change
Power lines
Pipelines
Wells
Military sites
Impervious surface

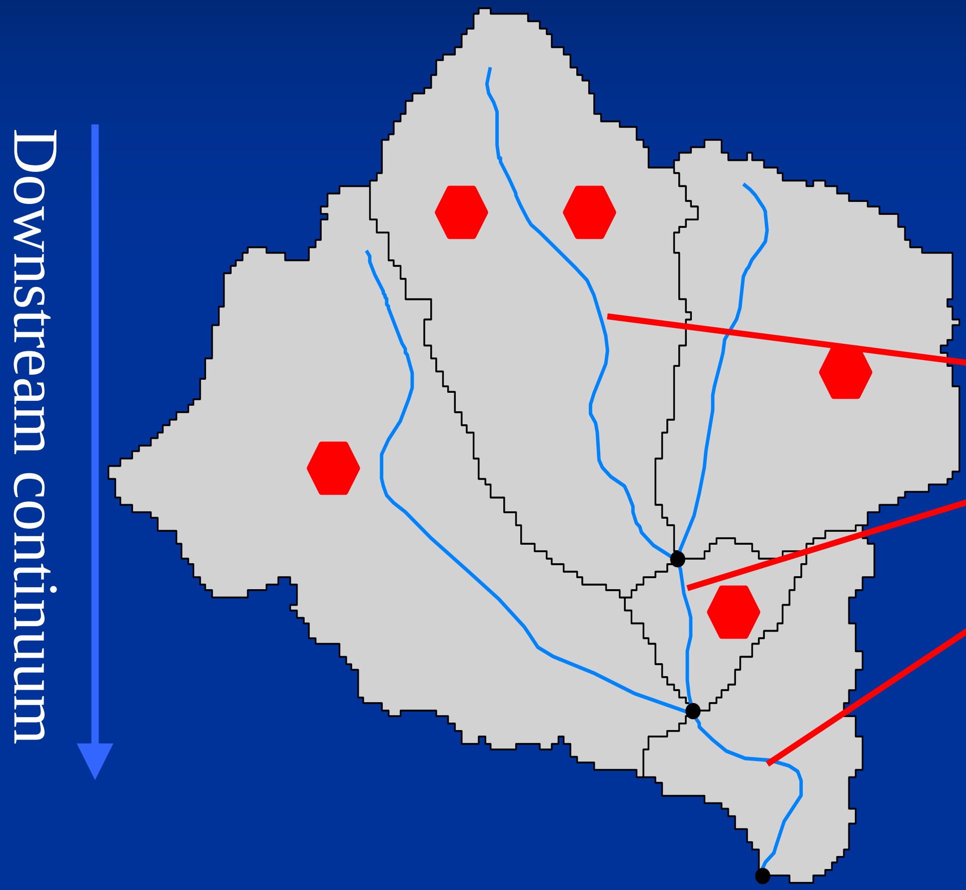
Discharge:
LUST
Superfund sites
TRI
NPDES
Landfills
Waste water treatment

Mining:
Lead mines
Coal mines
Other mines
Oil & gas wells

Quantifying Data

- Overlay threats and catchment polygons
- First, quantify locally
- Next, run programs to quantify everything in the drainage above <u>each</u> stream segment

Quantify Locally Then Everything Upstream



Toxic Releases

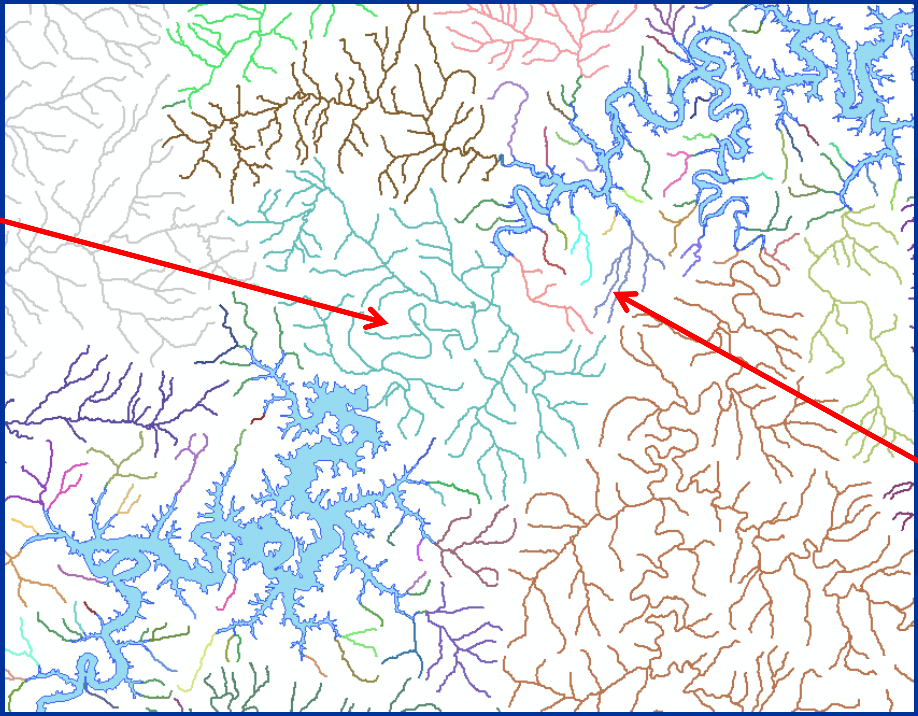
# Local	# In Upstream Drainage
2	0
1	3
0	5

- 1 to 1 relationship with stream segments
- Almost any properties of the watershed can be linked to the stream network for accumulation downstream

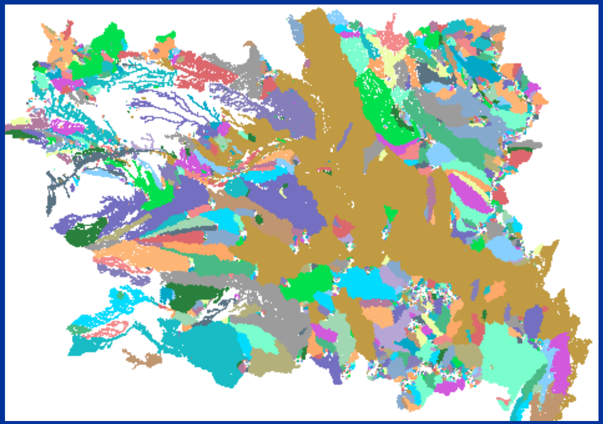
Connectivity / Fragmentation

- How fragmented are the steam networks due to dams/impoundments?
- Total length of interconnected stream
  - i.e. Miles of stream a fish has access to without going through a dam

221 Km of Stream

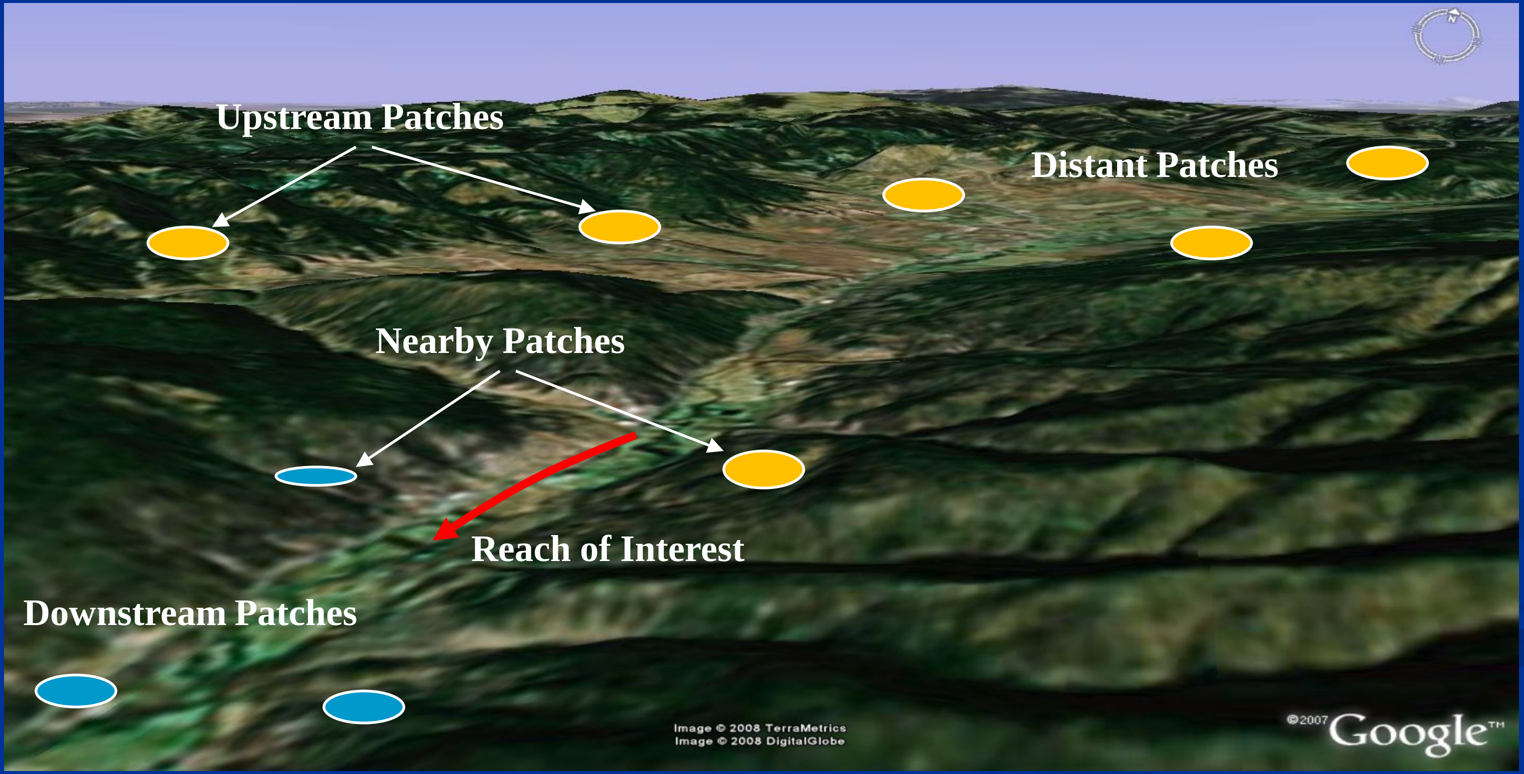


18.7 Km of Stream



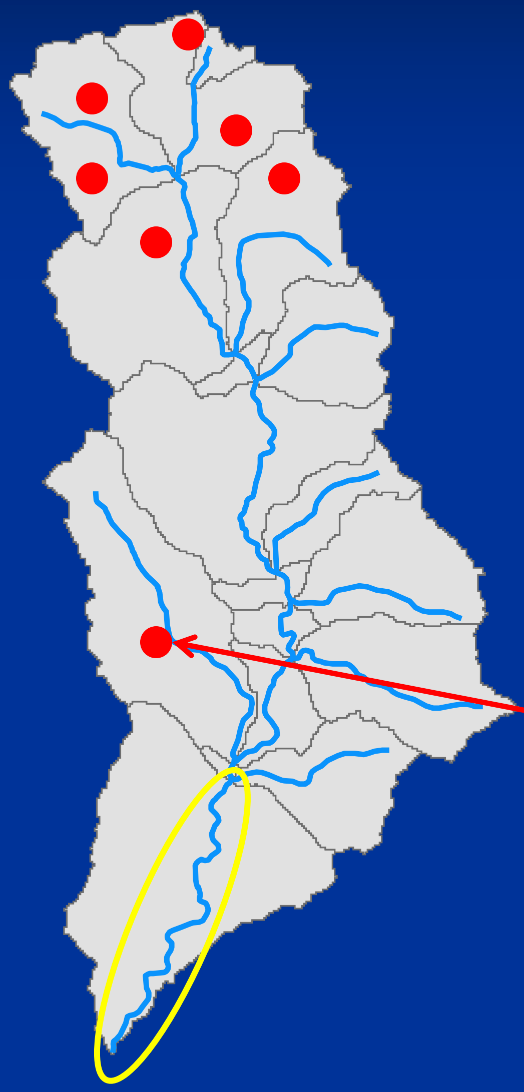
Spatial Distribution of Individual Threats is Important

- Is threat upstream, local, or both?
- Distance to threat



Ecological Integrity of Riverine Ecosystems is Dependent Upon Integrity of the Entire Watershed

Accounting for Distance



Mines

Mines Upstream	
Minimum Distance	3 Km
Mean Distance	16.5 Km

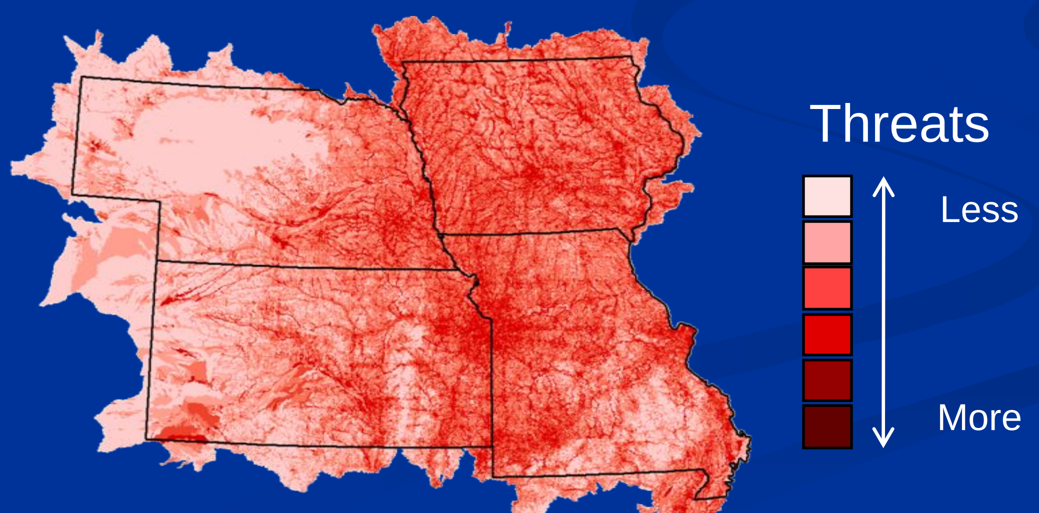
Rank Quantified Data

- Large table with info about each threat dataset
  - Local and upstream information
- Each will be assigned a relative rank

Example Only	Relative Ranks			
Metric	**1**	**2**	**3**	**4**
% Agriculture	0-25	26-50	51-75	>75
Density of Road-Stream Crossings (#/Sq. Km)	0-0.24	0.25-0.49	0.5-0.9	>=1
Population Change 1990-2000 (#/Sq. Km)	-42-0	0.1-14	15-45	>45
Density of Coal Mines (#/Sq. Km)	0	1-5	6-20	>20
Density of CAFOs (#/Sq. Km)	0	1-5	5-10	>10
Degree of Fragmentation	1	2-3	4-5	6
. . .				

Ranked Data Used to Create Overall Human Threat Index

Dam_rnk	Popchg_rnk	Coal_rnk	Lead_rnk	Cafo_rnk	Max	Sum	HTI
2	2	3	1	2	4	24	424
4	1	3	1	2	4	23	423
2	3	3	1	2	4	25	425
2	1	2	1	2	4	19	419
1	1	2	1	1	4	18	418
2	2	2	1	3	4	24	424
2	1	2	2	2	4	23	423
2	2	2	1	3	4	22	422
2	2	1	1	2	4	20	420
2	1	3	1	3	4	22	422
4	3	3	1	2	4	27	427



Account for Components of Ecological Integrity Separately

(Flow regime, Physical habitat, Water quality, Energy/Nutrient dynamics, Biotic interactions)

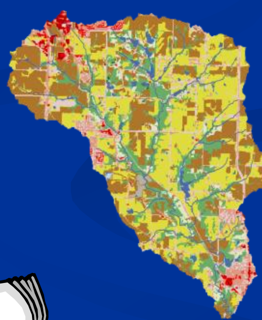
- Threat X impacts water quality, but has little impact on flow regime
- Threat Y impacts physical habitat, but has little impact on water quality
- Attempt to account for these separately

Resulting Products

- Human Threat Index (HTI)
- Geospatial data archive
- Raw data metrics
  - Related table of actual data
  - Allows display of region by any metric (i.e. mine density)
- Final report

Potential Use for Information

- Watershed inventory & assessment
- Monitoring – Selecting reference sites
- Landowner incentive programs
- Identifying information needs
- Education and Outreach



Progress Since Last Meeting

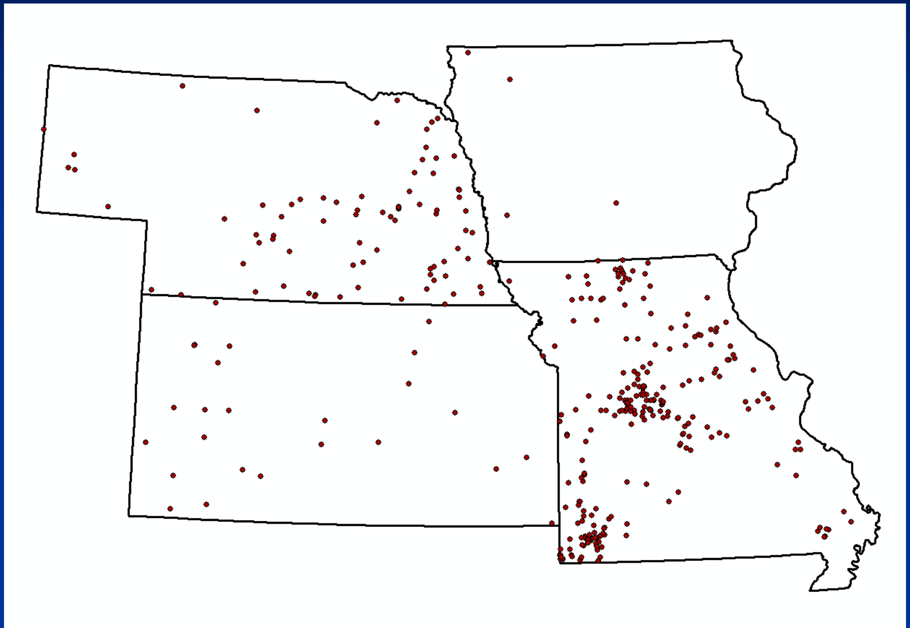
Recent Progress

- Various data issues fixed
- Created channelized streams dataset
- Completed computing distances to threats
- Created modified impervious surface
- Identified headwater impoundments
- Produced riparian buffers
- Dataset error checking complete
- Dataset reports

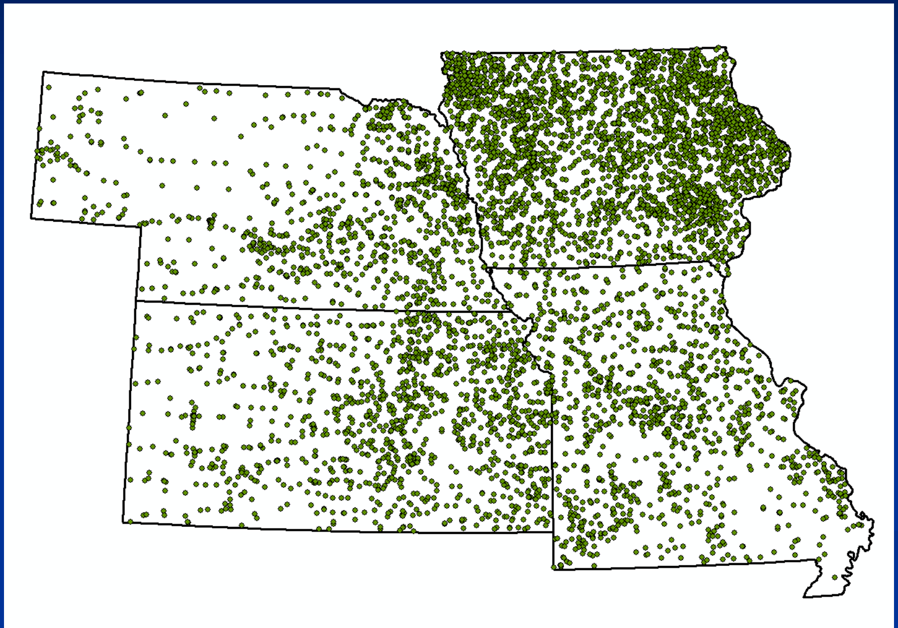
Data Issues:
Concerns Discussed at Last Meeting

1. CAFOs
2. NPDES
3. In-stream Mining
4. Channelization

Data Issues CAFOs



NPDES CAFO's



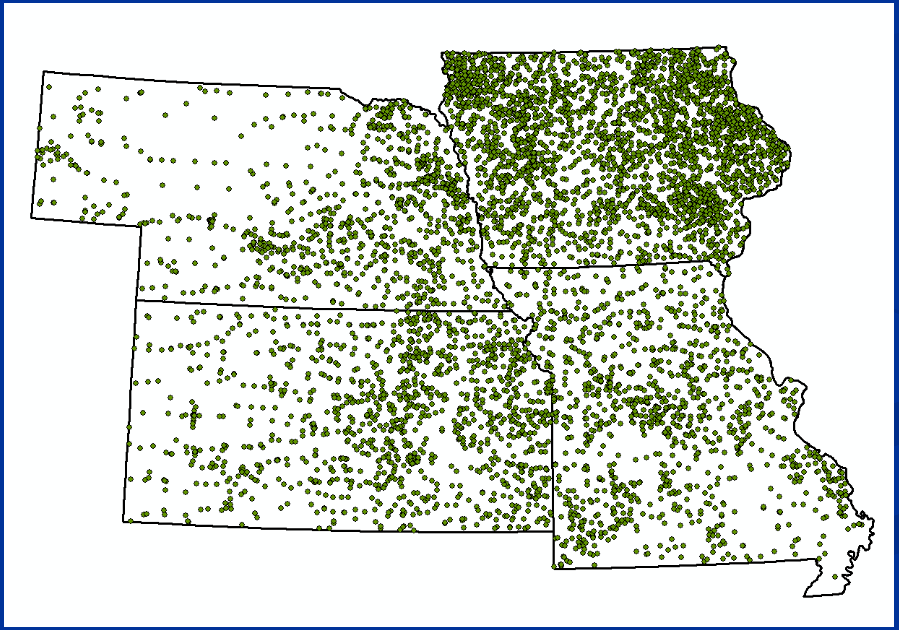
EPA CAFO's

1. Data is not consistent across region
2. Some CAFO's are missing
3. Some of the facilities are generalized for the region (i.e. 1 point for many facilities)

1. Data appears "consistent" across region
2. Misses some facilities
3. Often poor locational accuracy

Data Issues: CAFOs
What we did

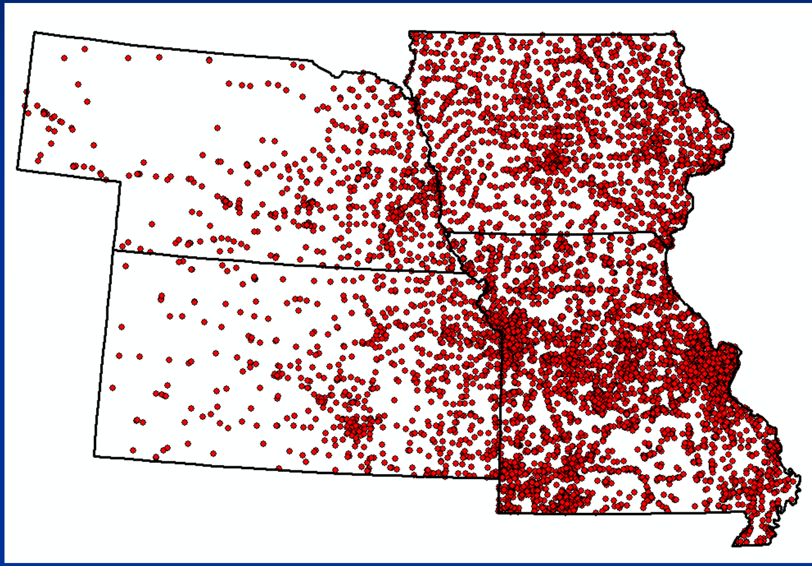
- Decision was made to use the EPA CAFO layer
  - Number of facilities in watershed
  - Total sales in watershed



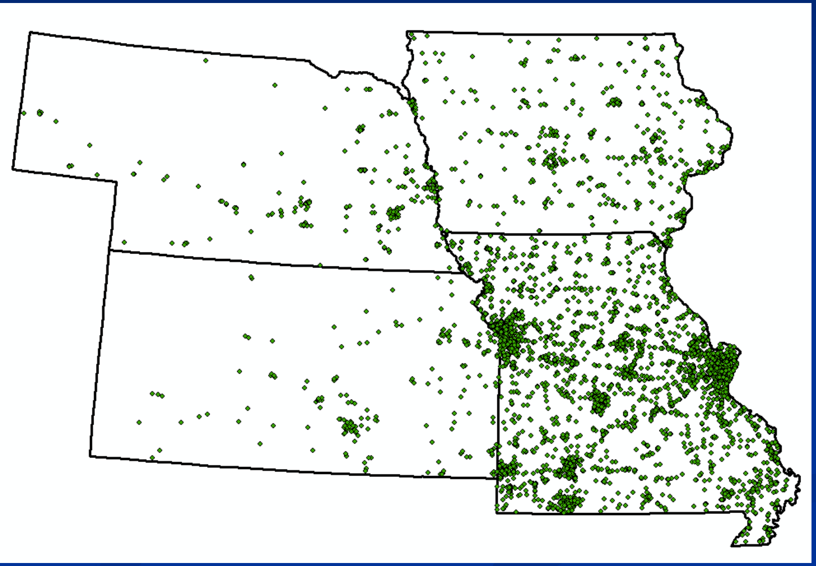
EPA CAFOs

Data Issues: NPDES

NPDES all data



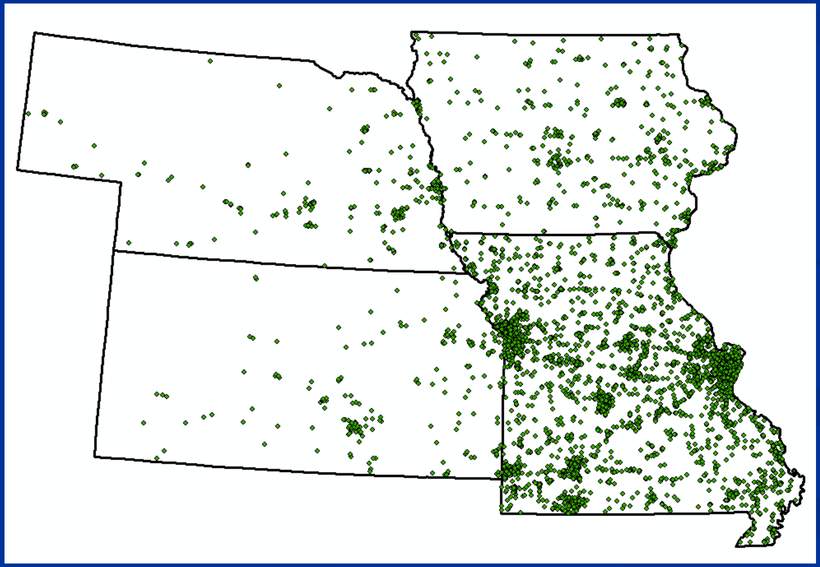
Overlap Removed



1. NPDES overlaps with other datasets we are using
2. Approximately half the data points remain after removing overlap
3. A large portion of the remaining points are due to construction site permits that are probably no longer there.
4. Other types of remaining points are service stations, farm supply stores and water supplies.

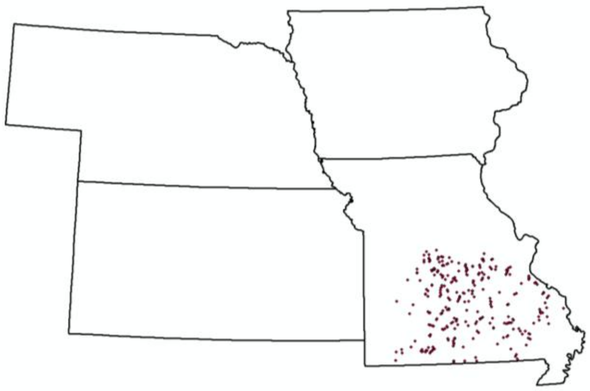
Data Issues: NPDES
What we did

- Group decided we should use remaining NPDES points
  - Excluded temporary construction sites



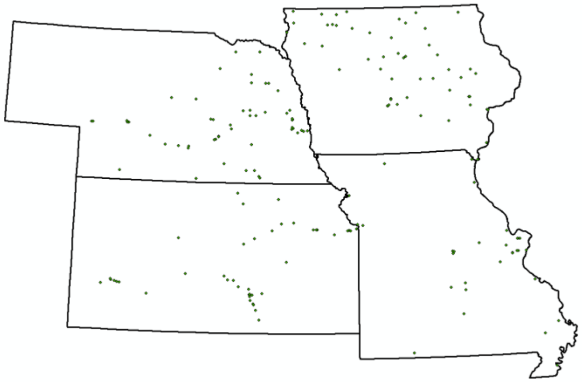
NPDES without Overlap

Data Issues: In-Stream Mines



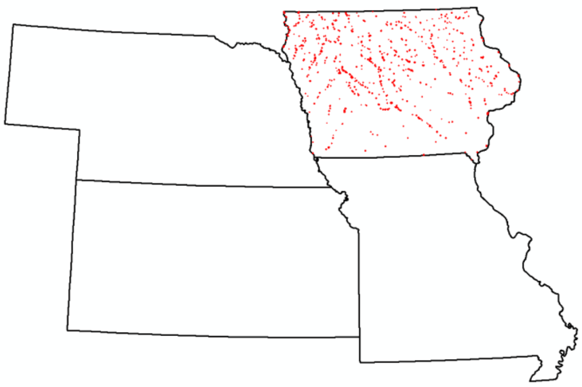
MO DNR - In stream mines

- Sand and gravel



Bureau of Mines Active Mines – Sand and gravel

- This data was extracted from the active mines data, it contains all sand and gravel mines.
- We understand that all sand and gravel mines should be in streams.

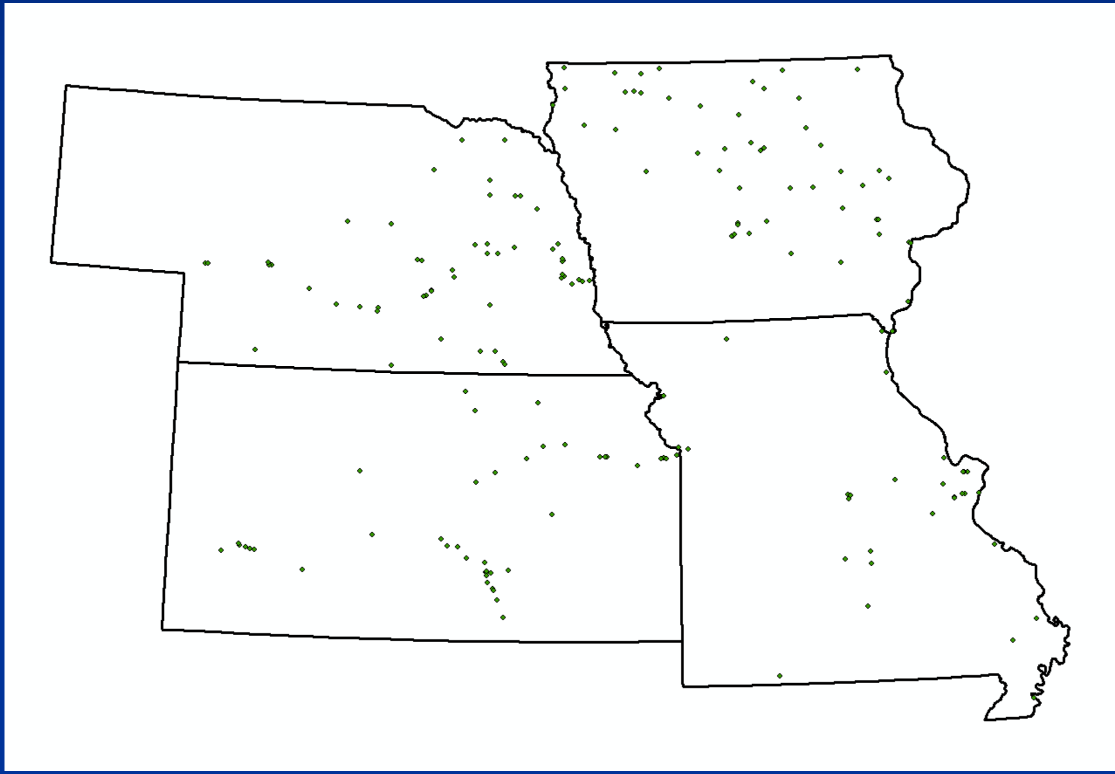


Iowa Mines 2000 – Sand and gravel

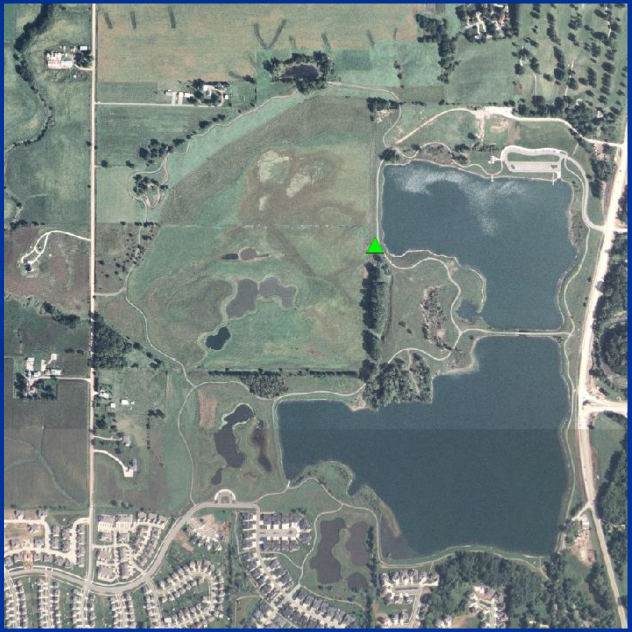
- This data was extracted from the Iowa Mines 2000 dataset, it contains only sand and gravel mines.

Data Issues: In-Stream Mines

Bureau of Mines
Active Mines



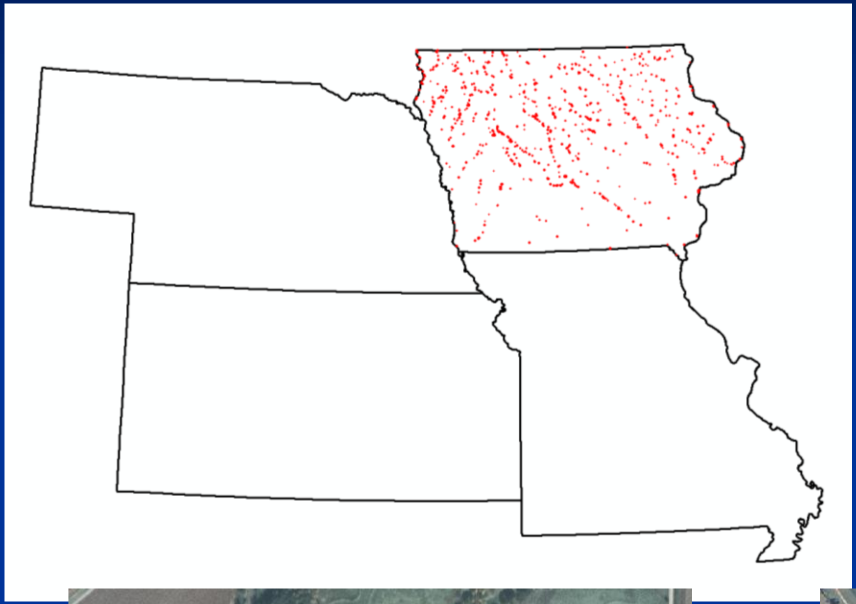
“In Stream” Mine?



The example to the right shows and in stream mining operation at a lake, the closest stream is about almost a mile to the east.

Data Issues: In-Stream Mines

Iowa Mines 2000



- Images show locations of sand/gravel mining operations
- However no visible evidence of any operation within the boundary of the mine.

Data Issues: In-Stream Mines

What we did

- Did not utilize in-stream mines
  - Too many missing
  - Property vs. active mines
- Any in-stream mines in Active Mines dataset were run with "other" mines

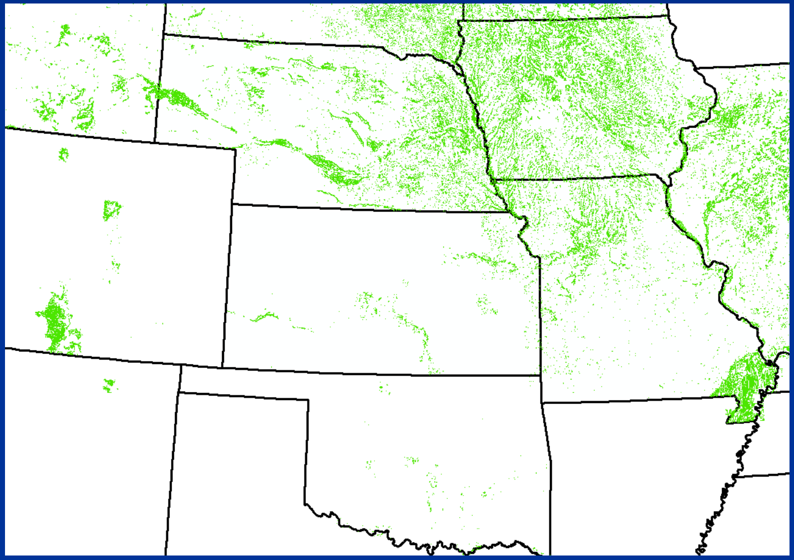
Data Issues: Channelization

- Sinuosity/straightness type programs
  - Introduce error
- Angle calculation
  - Introduce error
- NWI
  - Incomplete coverage for Region 7 (Kansas)
  - Misses some channelization/ditches
  - Different resolution lines
  - Attribution

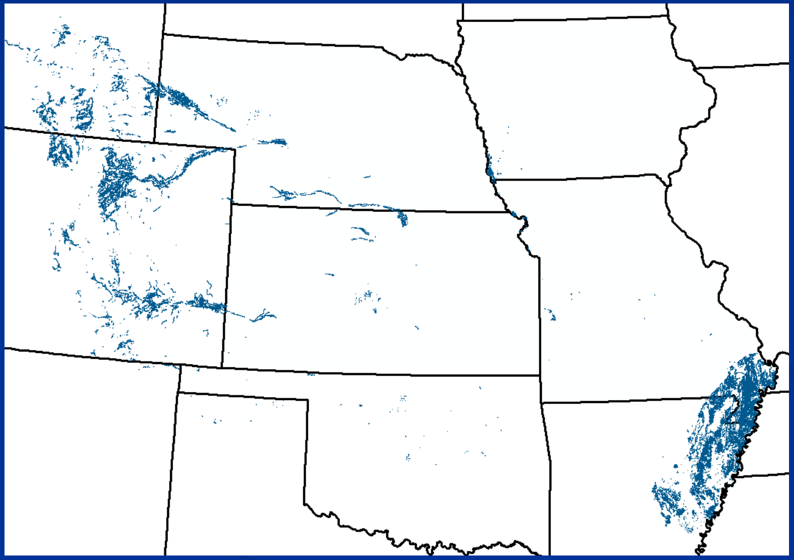
Data Issues: Channelization

What we did

NWI



24k NHD



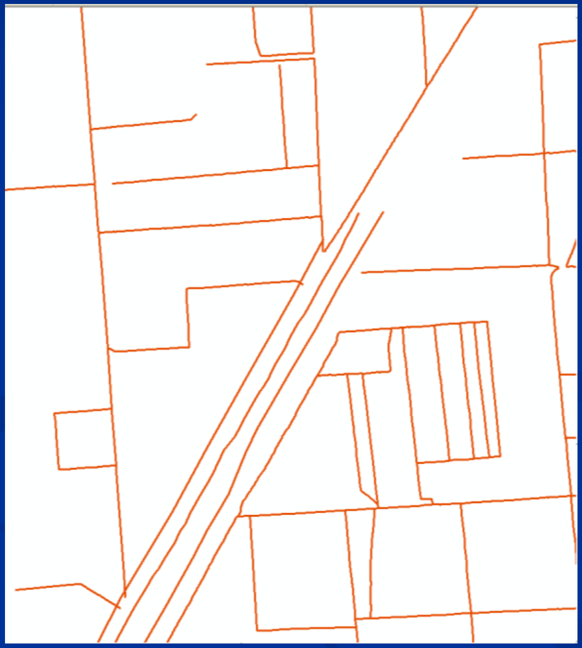
- Combined NWI and 24k NHD and removed overlap

Data Issues: Channelization

What we did

NWI and NHD streams (with overlap)

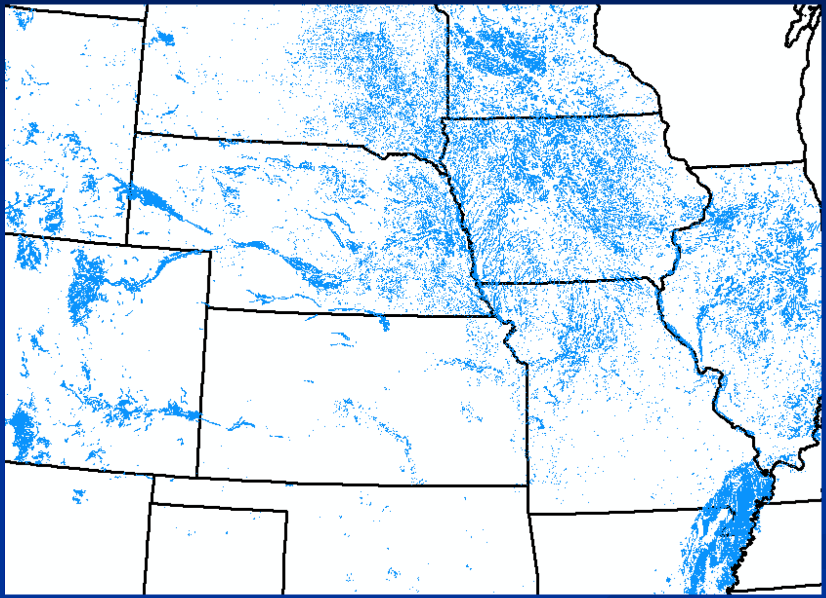
Merged stream file (overlap removed)



- Buffered the NHD streams by 100m
- Maintained any NWI stream that did not have its centroid in the buffers

Data Issues: Channelization

What we did



NWI + 24k NHD = High Resolution ditch layer

- Used the ditches from NWI and 24k NHD to tag 100k NHD streams
- Computed total length of ditch using the "high resolution" ditches

Accounting for Distance

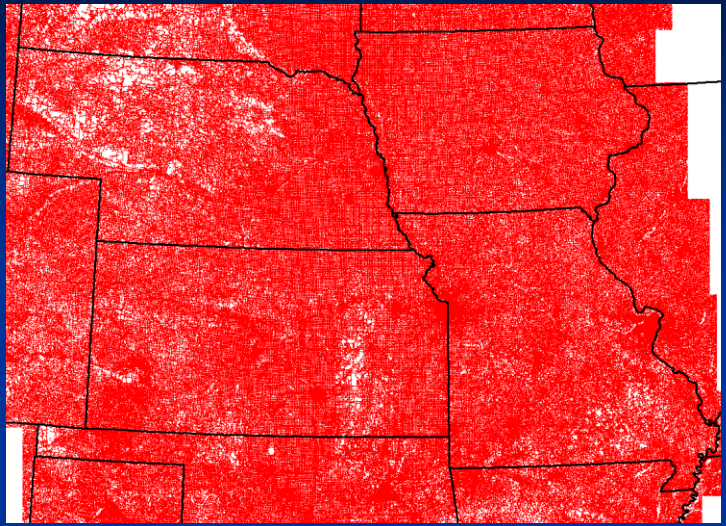
Completed Distance Computations

Average and Minimum Distances

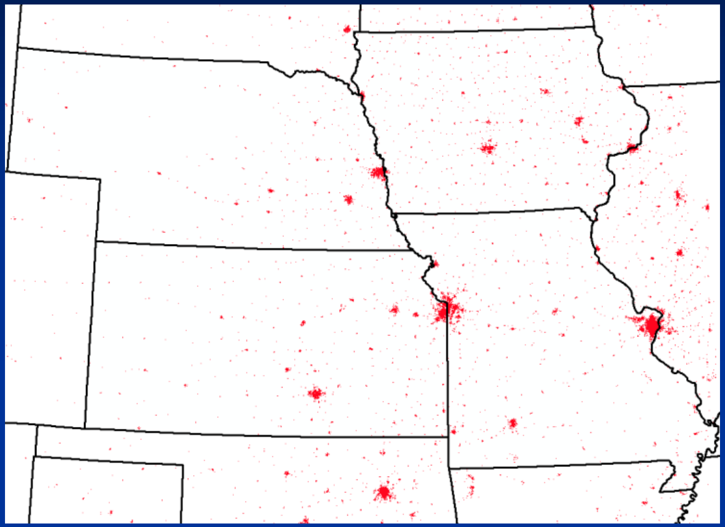
- Airports
- Dams
- Military Sites
- Coal mines
- Lead mines
- Leaking underground Storage Tanks
- Mines
- Oil and Gas Wells
- Superfund Sites
- Toxic Releases
- Waste Water Treatment Facilities
- CAFO's
- Landfills
- NPDES Sites
- RCRIS Sites

New/Improved Source Data

Impervious Surface



NLCD Impervious



Modified for Use

- NLCD pixels tagged as being 1 to 100% impervious
- We wanted to remove roads

Impervious Surface

Wanted to exclude "roads" from impervious layer

Roads are already accounted for

A 30 meter pixel is too large to accurately represent most roads

Impervious Surface

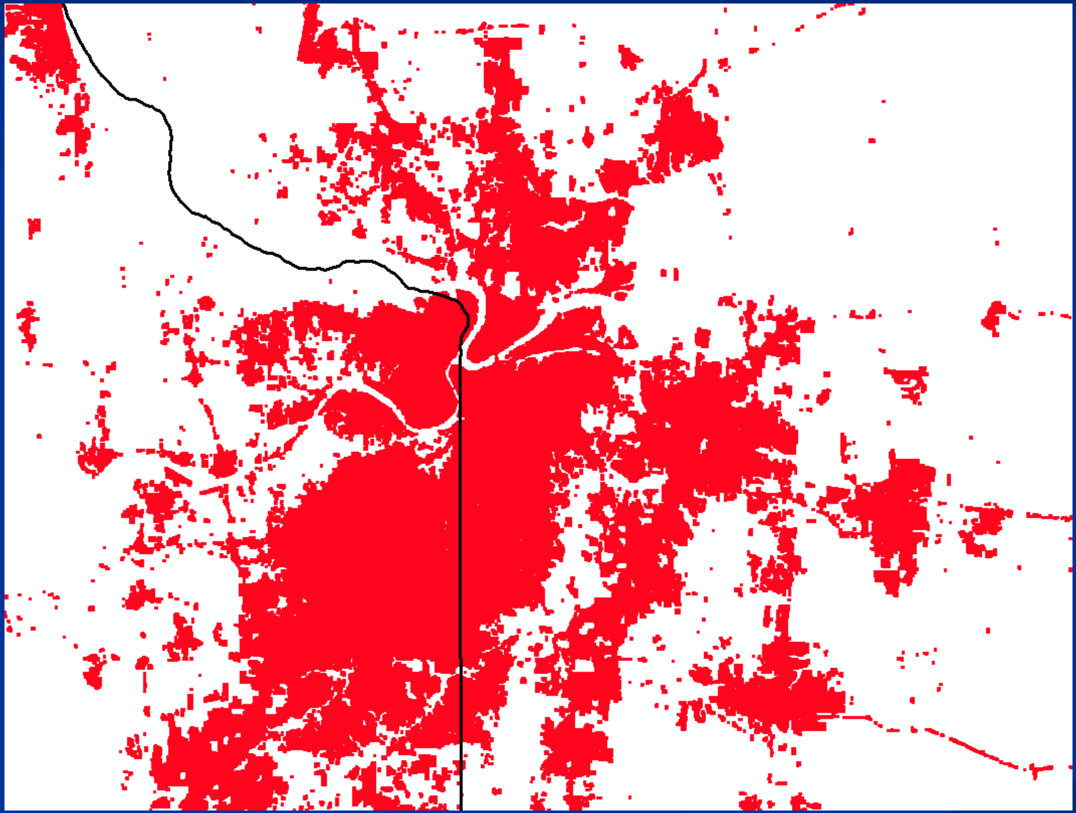
Original 2001 NLCD Urban Area

- Step 1
    - Shrink the raster by 3 pixels to remove most roads.

Remaining impervious surface data

- Step 2
    - Expand the raster by 3 pixels to restore lost areas of data around larger impervious areas.

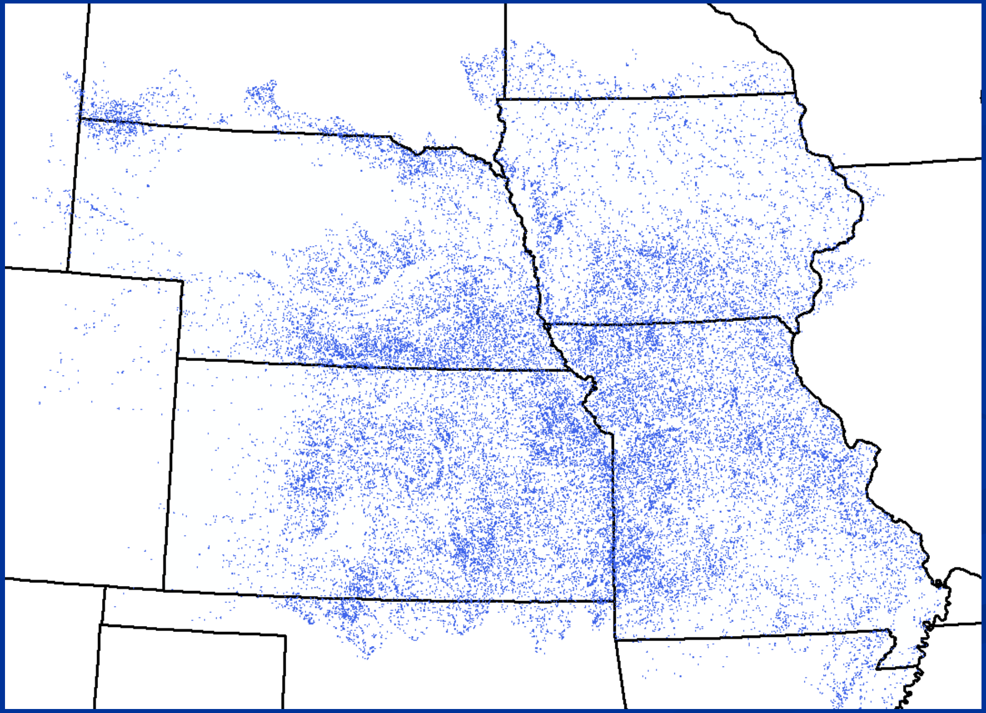
Resulting final file



Kansas City

Headwater Impoundments

- Did not exist for EPA Region 7
- Created a new layer using various sources

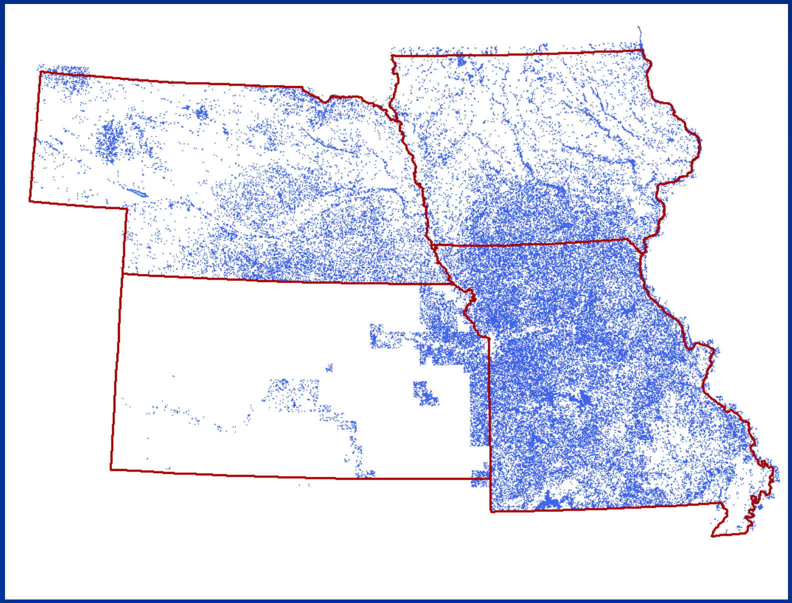


MoRAP Headwater Impoundments

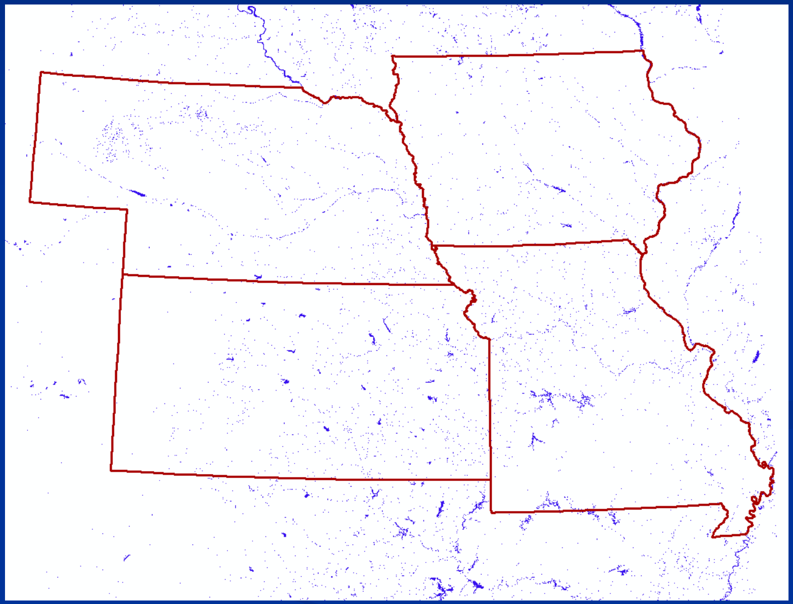
Headwater Impoundments

Waterbody Source Data

NWI

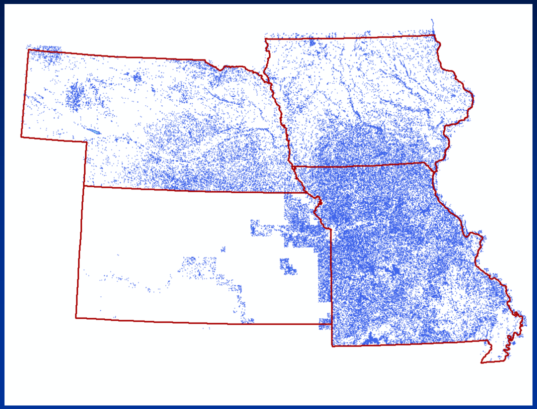


NLCD



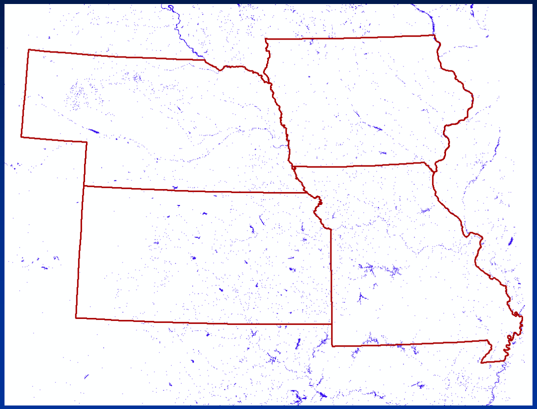
- We subset these data sources to pull out "headwater impoundments"

Headwater Impoundments



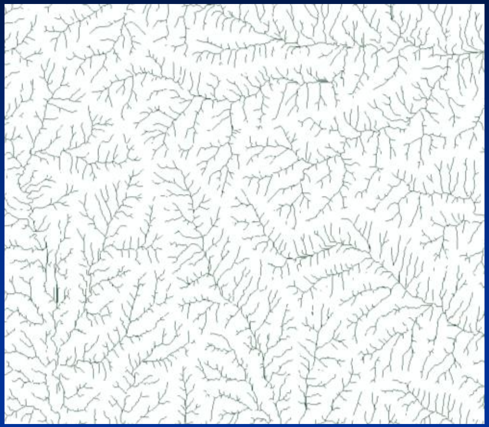
NWI

+

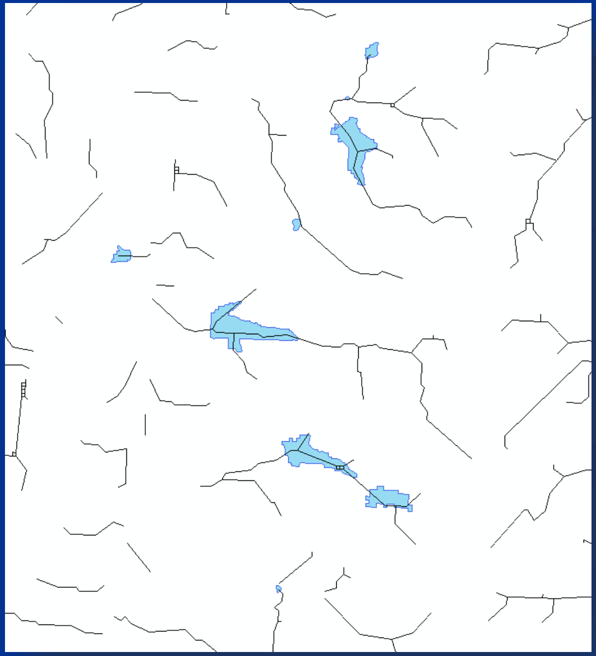


NLCD

+

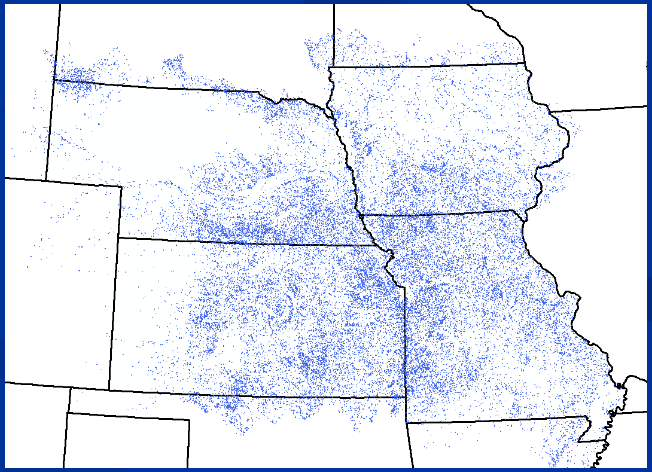


300 Cell Stream Network



Headwater Impoundments

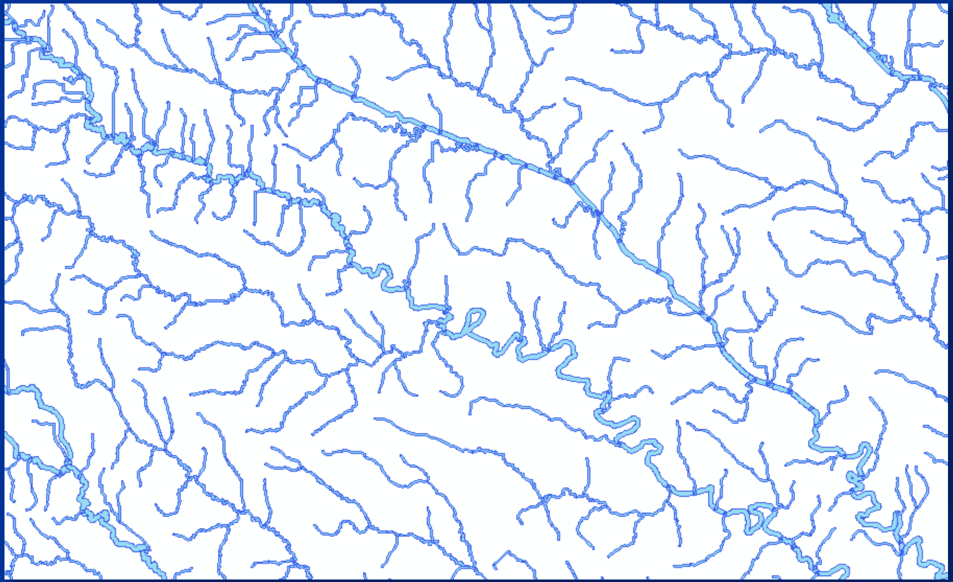
- Wanted to exclude "natural lakes"
  - Performed intersection with Iowa's natural lakes layer and Kansas playa lakes layer
  - Removed all non-dam lakes from the Sand Hills of Nebraska
  - Used professional judgment to manually remove other "natural" lakes



End Result

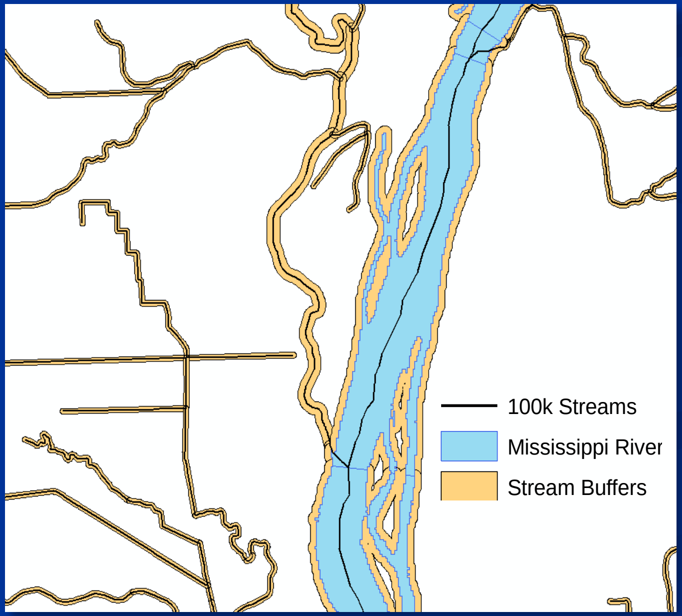
Riparian Buffers

- Wanted to quantify landcover within a stream buffer
- Headwater and Creeks were buffered by 45m and Small and Large rivers were buffered by 105m

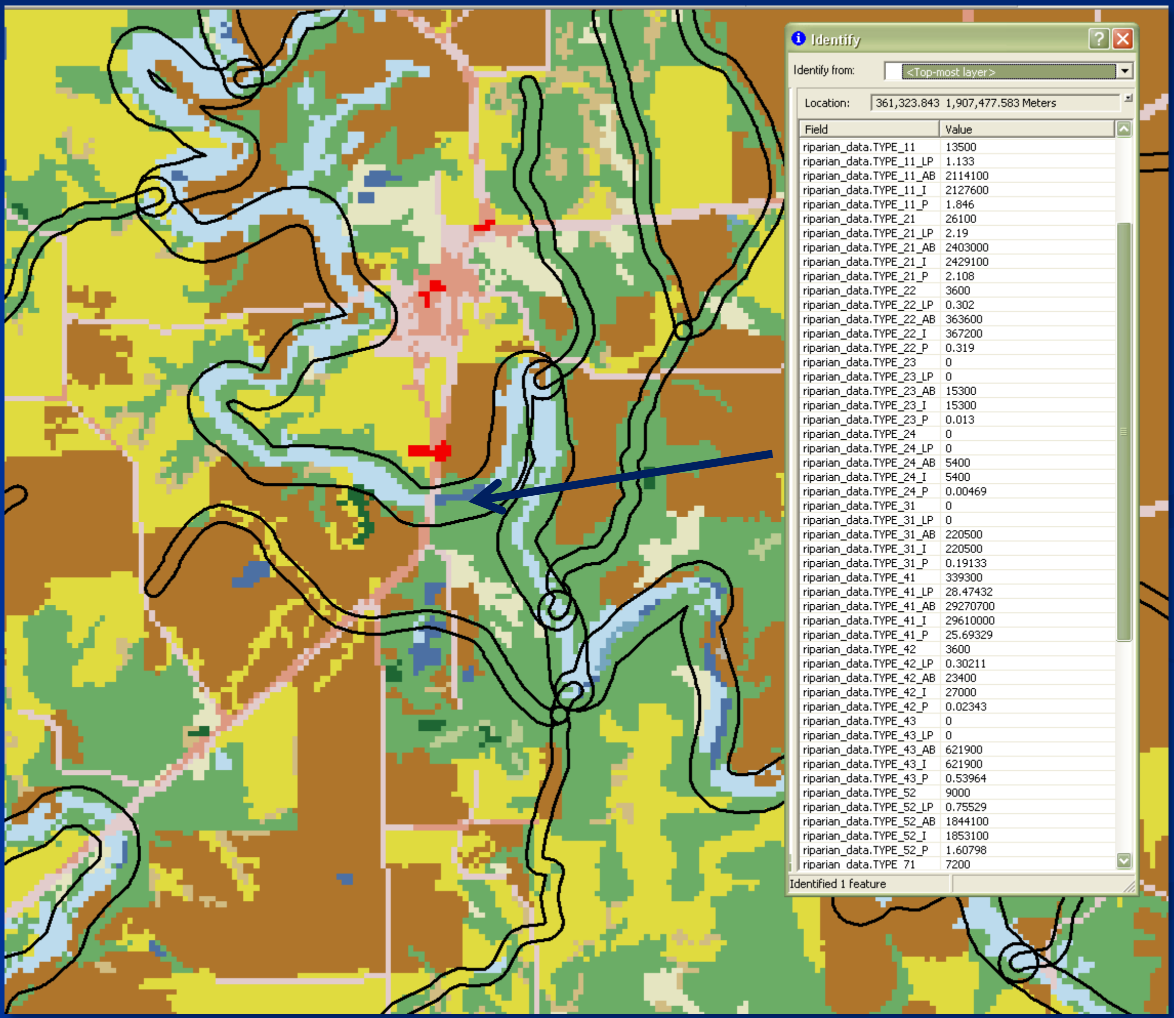


Riparian Buffers

- Different process for Missouri and Mississippi Rivers
  - Extracted from NLCD
  - Clipped manually to stream segments
  - Resulting polygons buffered by 105 meters



Riparian Buffers

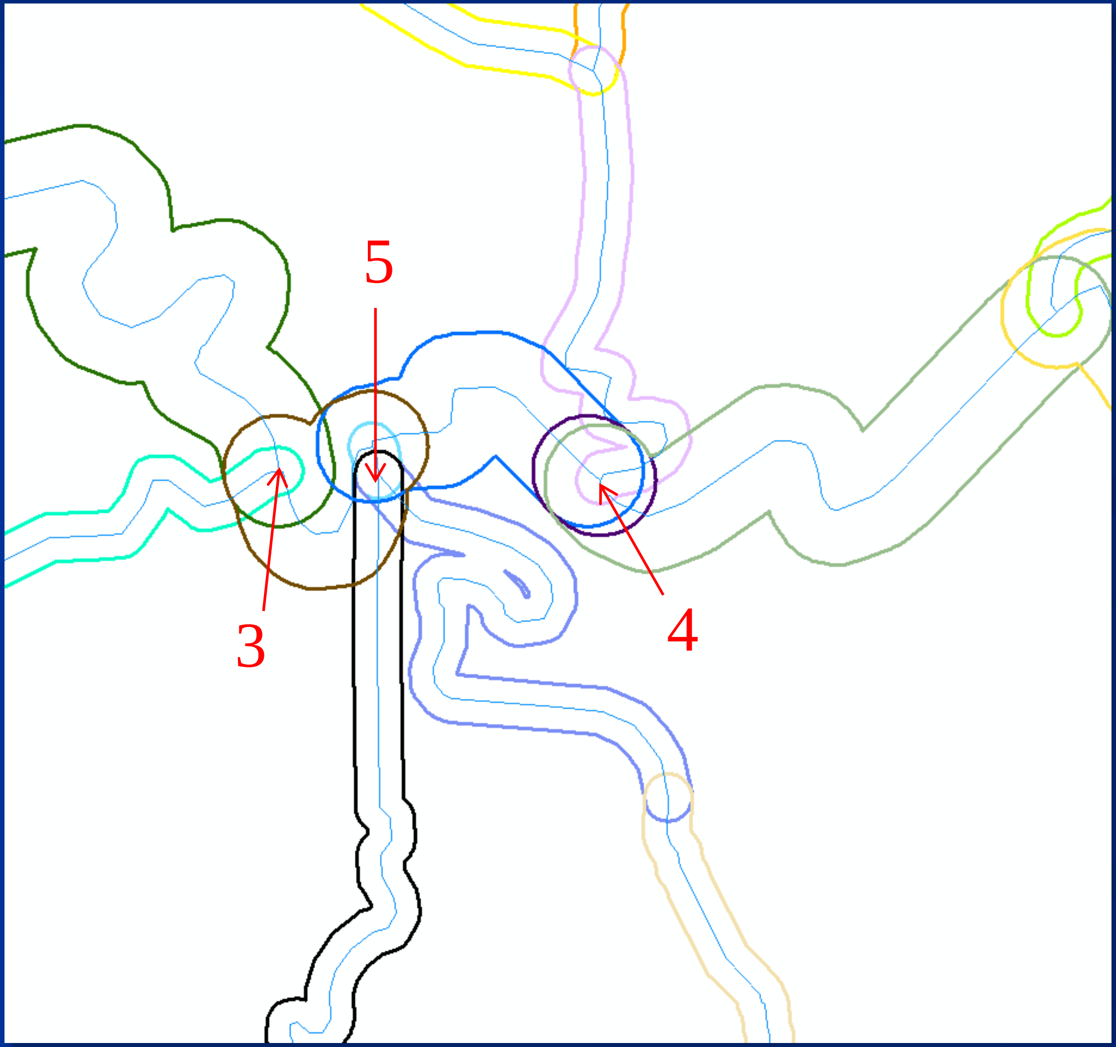


Riparian Buffer Land Cover (2001 NLCD)

- Local tabulated amounts of each class.
- Local percentage of stream buffer in each class.
- Total amount above each reach in each class.
- Total amount of watershed in each class.
- Total percentage of watershed in each class.

Riparian Buffers

Issues for Accumulation



Areas at stream confluences will get tabulated multiple times.

Several methods were attempted to fix this issue, and each method introduced its own type of error.

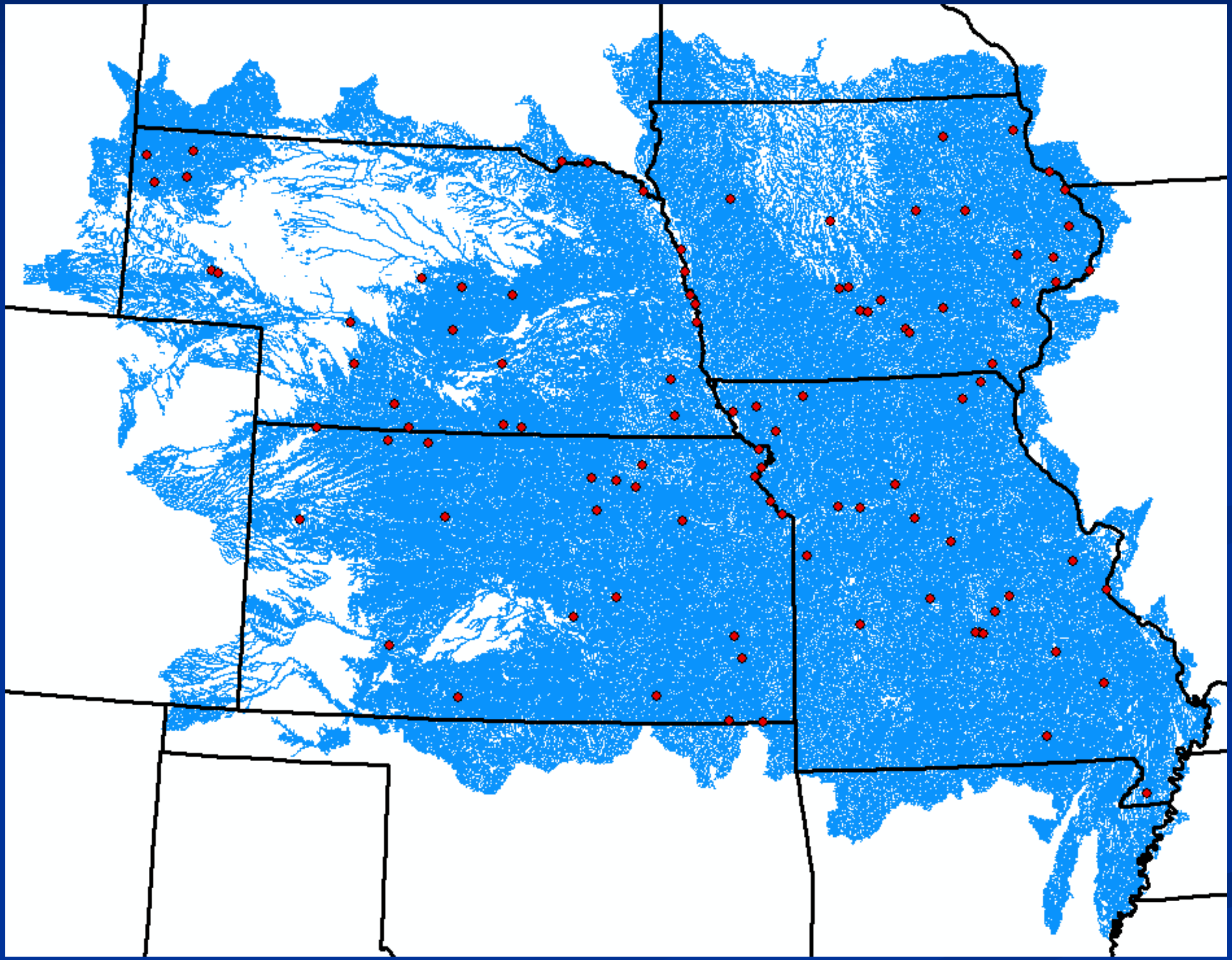
Riparian Buffers

Issues for Accumulation

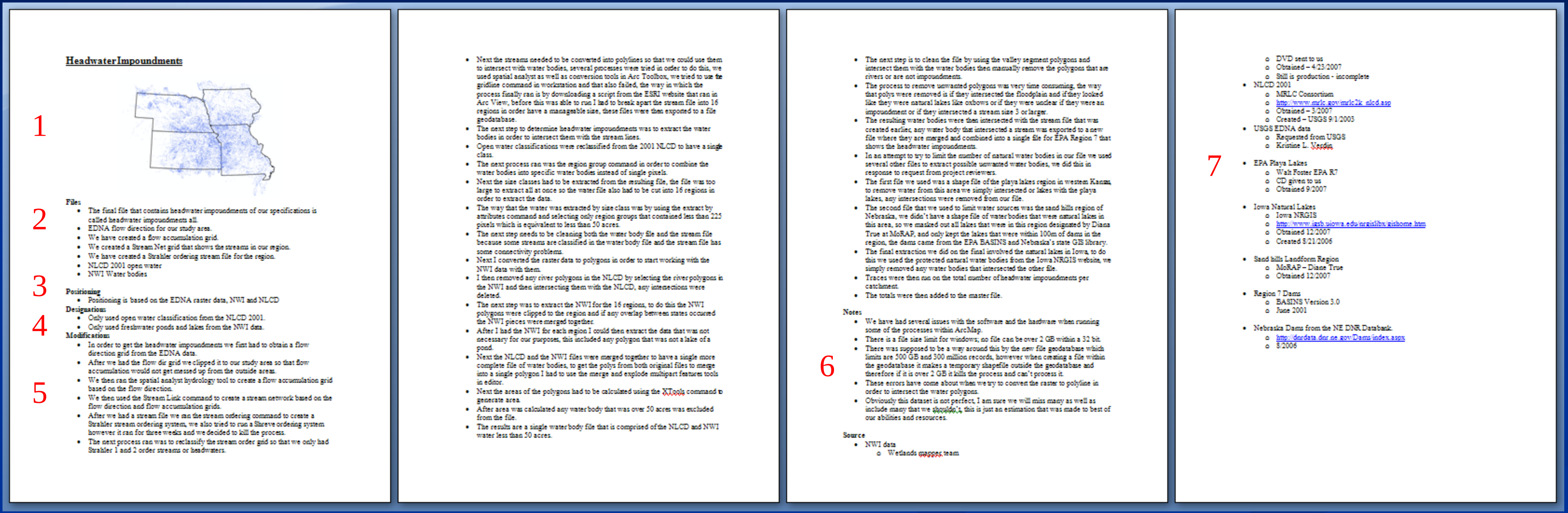
- Were not going to use the traces for buffers because of overlap issue
- However, . . . Decided to do so
  - Still yields useful information for what is in upstream riparian area

Error Checking

100 Random Locations - Complete



Dataset Reports



For every dataset there is a corresponding report that contains:

1. Reference Map
2. Files Used
3. Position Information
4. State Designations
5. Modifications or Process Steps
6. Notes
7. Source Information

Still Working On

- Human Threat Index (HTI)
- Developing separate index for 5 components of ecological integrity
- Field validation

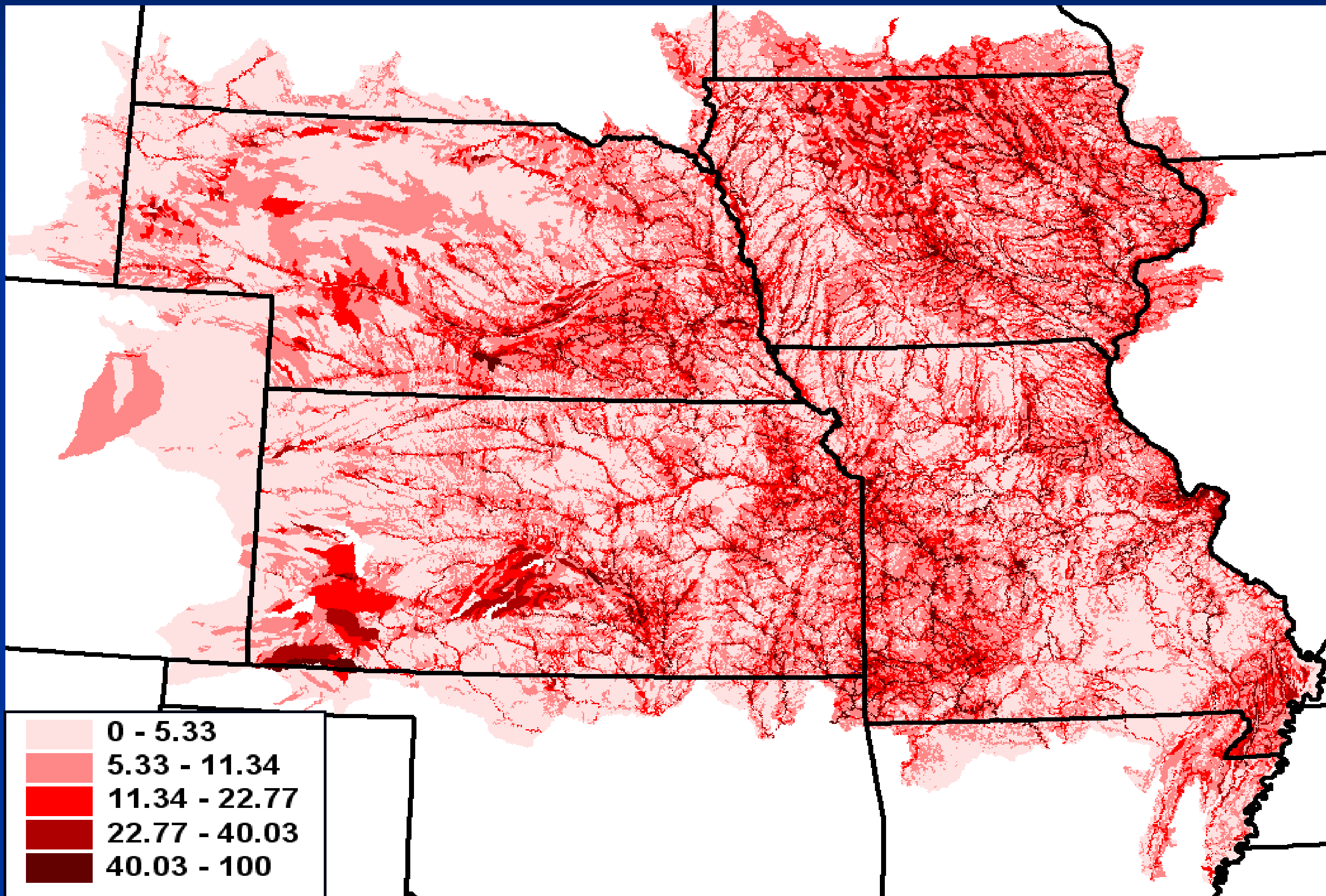
Open Discussion

Data & Methods

Human Threat Index

Methods and Discussion

Preliminary Draft Human Threat Index



HTI Inputs

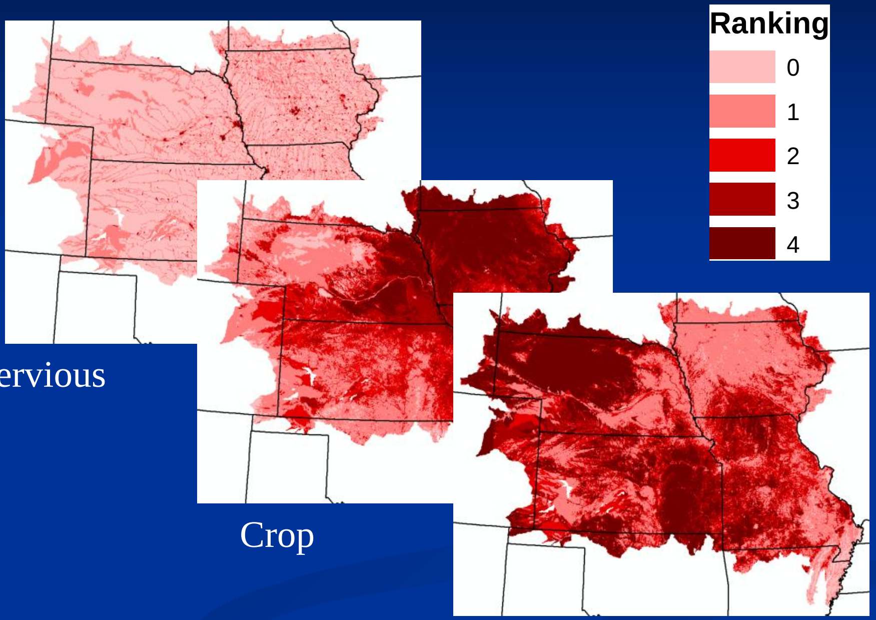
1. Impervious
2. Cropland
3. Pasture
4. Impervious in stream buffer
5. Crop in stream buffer
6. Pasture in stream buffer
7. Length of road
8. Road/stream crossings
9. Wells
10. Major impoundments
11. Pipelines (crude oil)
12. Pipelines (liquid fuels)
13. Pipelines (natural gas/propane, etc.)
14. Length of rail
15. Rail/stream crossings
16. Power lines
17. Pesticide applications
18. Headwater impoundments
19. Livestock sales
20. Length of ditch
21. Airports
22. Dams
23. Military sites
24. Coal mines
25. Lead mines
26. Other mines
27. LUST
28. Oil & gas wells
29. Superfund sites
30. TRI
31. Waste water treatment
32. CAFOs
33. Landfills
34. NPDES
35. RCRIS
36. Population change
37. Fragment size
38. Stream size classes per fragment
39. Distance above lake

Individual Threat Classes

- Used five class ranking
  - 0 – 4
  - 0 usually reserved for “none”
  - Literature often used 4 or 5 classes

Ranking Individual Threats

- Used literature for
  - % Impervious
  - % Crop
  - % Pasture



Impervious

Crop

Pasture

Rank	% Impervious	% Crop	% Pasture
0	0	0	0
1	0 - 5	0 – 10	0 – 20
2	5 - 15	10 – 30	20 – 40
3	15 - 30	30 – 70	40 – 60
4	> 30	> 70	> 60

Ranking Individual Threats

- Most other threats – Percentile groups
- Zeros held out
- Number of classes?
- Class breaks vary by threat?
  - Prevalence on landscape determines rank

Rank	Percentile Group
0	No features
1	Less than 25^{th}
2	25^{th} – 50^{th}
3	50^{th} – 75^{th}
4	> 75th

Ranking Individual Threats

Class Breaks Vary by Prevalence

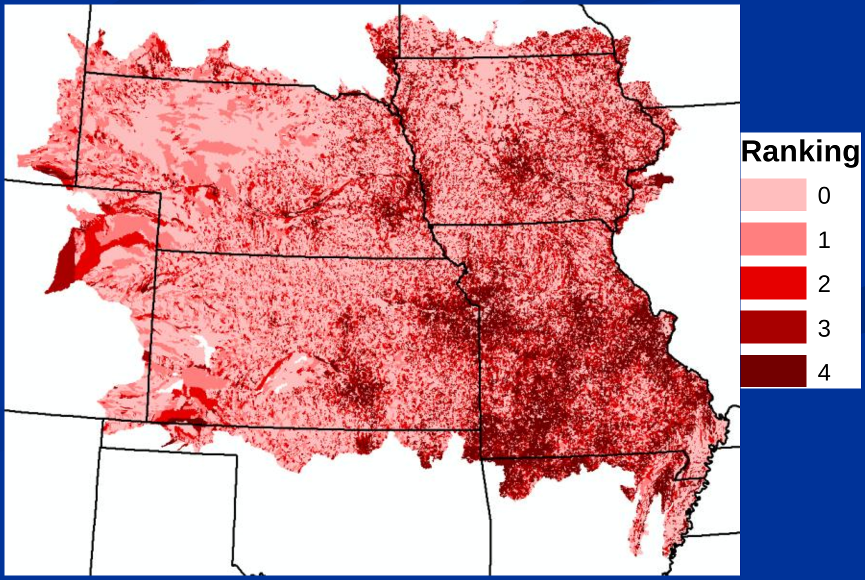
- Threat A
  - Density range 1 – 1000
  - Class 1 (low): 1 – 250
- Threat B
  - Density range 1 – 100
  - Class 1 (low): 1 – 25
- Threat B's class 4 (high) is compares to Threat A's class 1 (low)
- Is this something to avoid? Can we?

Things Ranked Differently

- Population change
  - Did not use “total population”
- Fragmentation from dams/impoundments
  - Various components

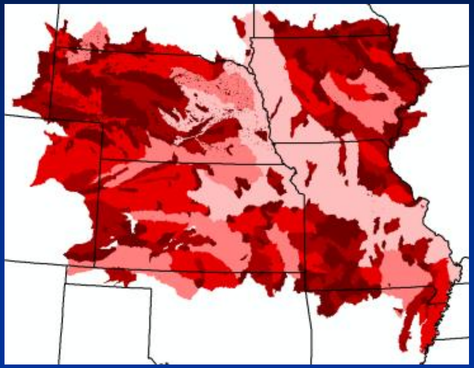
Population Change

- Population loss in watershed from 1990 – 2000
  - Considered "good"
  - Assigned rank of zero
- Positive population change
  - Percentile breaks
  - Ranks of 1 - 4

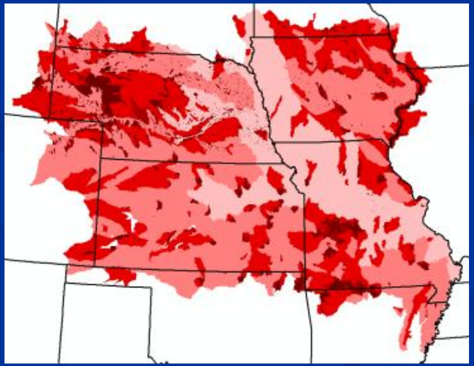


Fragmentation from Dams

- Two components considered
  - Fragment size
    - Bigger is better
  - Number of stream sizes contained in each fragment
    - More is better
- Also
  - Distance above lake
    - Greater is better
    - Inundated is worst
  - Distance below lake



Fragment Size



Size Classes in Fragment

Using Distance Weights for HTI

Distance Weighting

Step 1:

- Wanted to incorporate both Minimum and Average distance
- Created distance classes

Rank	Minimum Distance	Average Distance
15	0 - 2	0 - 2
7	2 - 10	2 - 10
3	10 - 100	10 - 100
1	> 100	> 100
0	None	None

Distance Weighting

Step 2:

- Density in watershed x Min rank x average rank
- Result ranked by percentiles; zeros held out

Mine Density (#/Km2)	Minimum Dist. Rank	Average Distance Rank	Distance weighted Score	Final Rank
0	0	0	0	0
0.03	3	1	0.09	1
0.03	7	3	0.63	2
0.03	3	15	1.35	3
0.03	15	15	6.75	4

Rank	Minimum Distance	Average Distance
15	0 - 2	0 - 2
7	2 - 10	2 - 10
3	10 - 100	10 - 100
1	> 100	> 100
0	None	None

Things <u>not</u> Distance Weighted

- Landcover (all classes)
- Pesticide application
- Linear features (roads, pipelines & rail roads)
- Population change
- Fragmentation from dams/impoundments
- Wells (too many to do)
- Headwater impoundments (too many)
- Road/stream crossings (too many)

Creating the "Index"

Methods and Discussion

Bringing it all Together

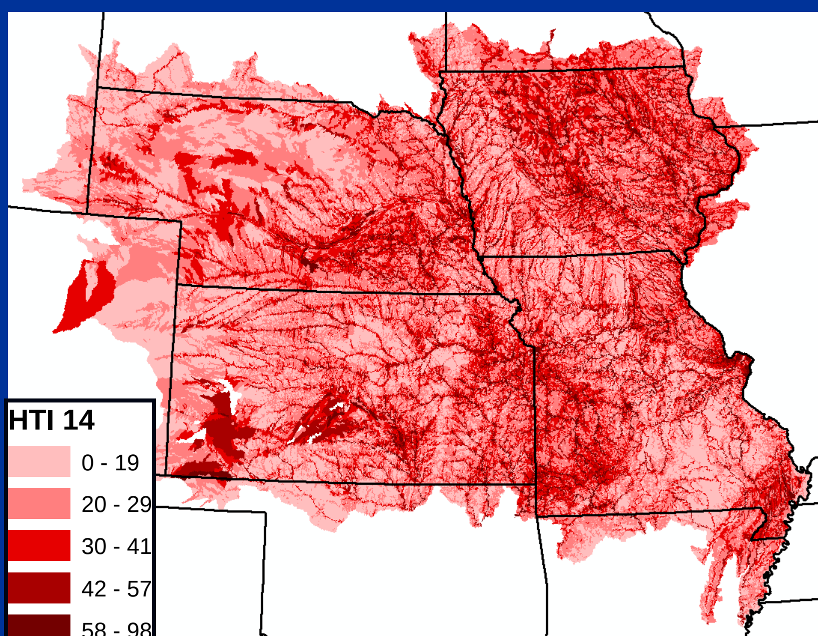
- Individual ranks are added together
- Result multiplied by mean rank and max rank
- Rescaled from 1 to 100

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	NPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	4	2	3	4	4	4	2	4	4	3	98	2.72	4	1067.11	100
1	4	4	3	3	2	4	4	4	4	4	4	0	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.44	97.97
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	3	2	3	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	1024	95.96
1	4	4	4	1	3	3	4	4	2	4	4	3	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4	3	95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4	3	95	2.64	4	1002.78	93.97
0	4	4	4	3	0	4	4	4	4	4	4	0	95	2.64	4	1002.78	93.97
0	4	4	3	2	0	4	4	4	4	4	4	0	94	2.61	4	981.78	92
0	4	4	3	3	3	4	4	4	1	3	3	4	93	2.58	4	961	90.06
0	4	4	3	3	3	4	4	4	1	3	3	4	93	2.58	4	961	90.06
1	4	3	3	2	2	4	3	4	4	4	4	0	93	2.58	4	961	90.06

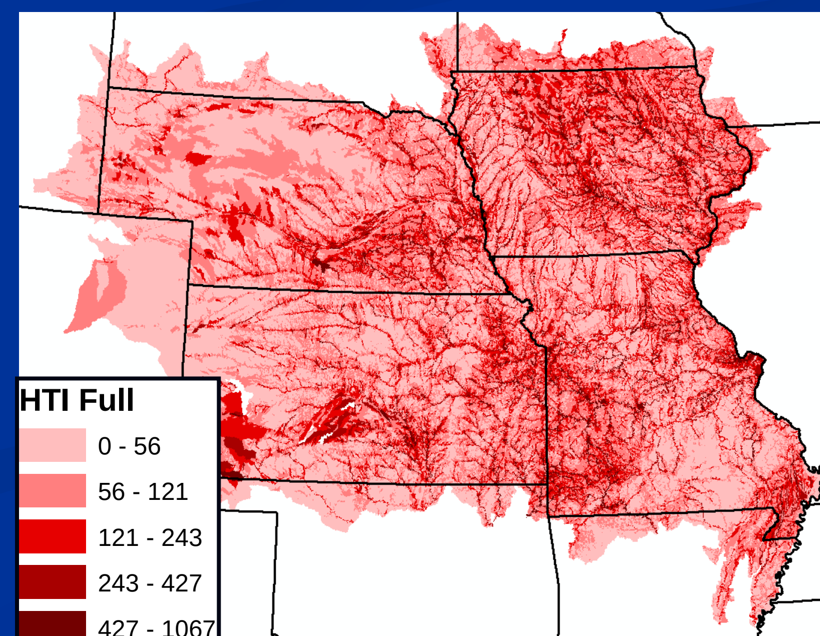
Raw HTI

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	NPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	3	3	3	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	4	2	3	4	4	4	2	4	4	[illegible]	98	2.72	4	1067.11	100
1	4	4	3	3	2	4	4	4	4	4	4	[illegible]	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	[illegible]	97	2.69	4	1045.44	97.97
1	4	4	3	3	2	4	4	4	2	4	4	[illegible]	97	2.69	4	1045.44	97.97
1	4	4	3	2	2	4	4	4	4	4	4	[illegible]	96	2.67	4	1024	95.96
1	4	4	3	3	2	3	4	4	4	4	4	[illegible]	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	[illegible]	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	4	4	4	[illegible]	96	2.67	4	1024	95.96
1	4	4	4	1	3	3	4	4	2	4	4	[illegible]	96	2.67	4	1024	95.96
1	4	4	3	2	2	4	4	4	2	4	3	[illegible]	95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3	[illegible]	95	2.64	4	1002.78	93.97
1	4	4	3	2	2	4	4	4	2	4	3	[illegible]	95	2.64	4	1002.78	93.97
1	4	4	3	1	3	3	4	4	2	4	4	[illegible]	95	2.64	4	1002.78	93.97

Individual Threat Ranks Summed

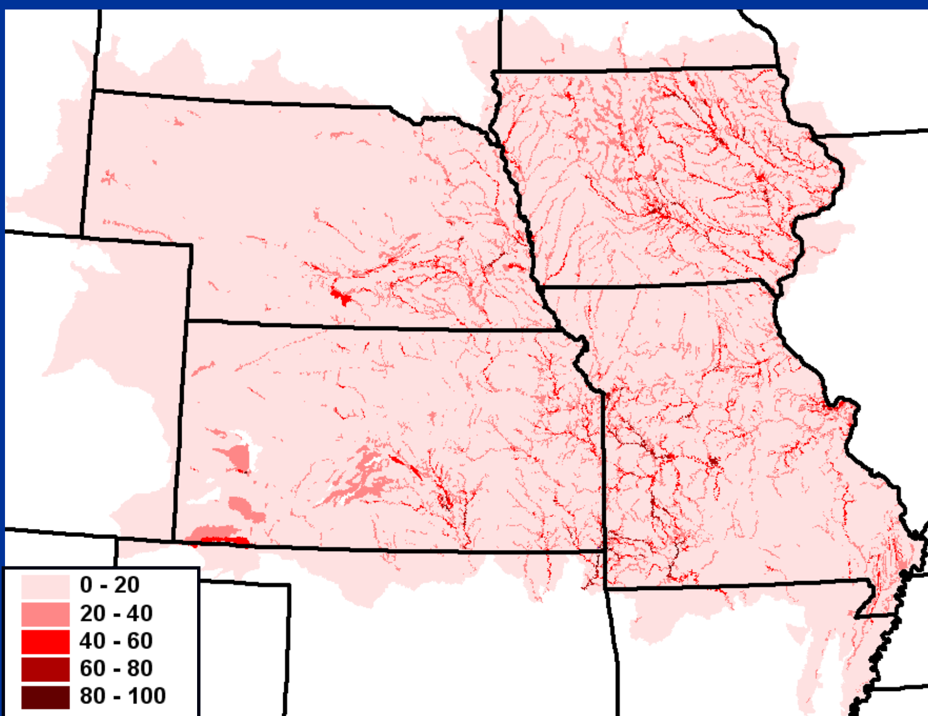


. . . And multiplied by mean & max

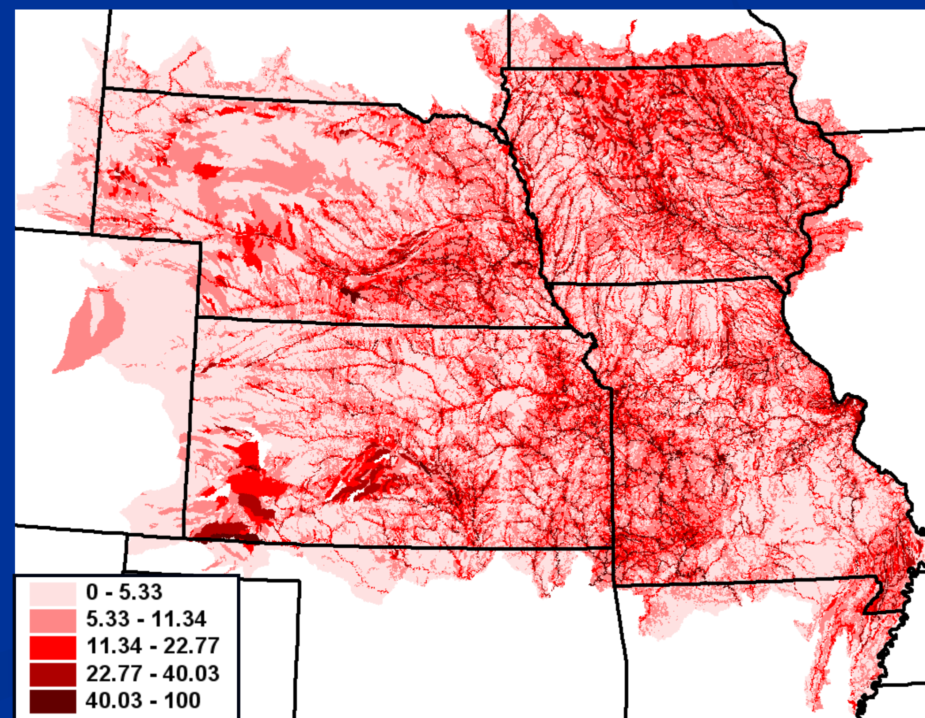


HTI Different Perspectives

R	SUPER_R	TRI_R	WWTF_R	CAFO_R	LNDFIL_R	NPDES_R	RCRIS_R	POPDIF_R	CLASS_R	FRAGSZ_R	LKDIST_R	CNT_SIZE	HTI_14	MEAN_14	MAX_14	HTI_FULL	HTI_RESCAL
1	4	4	4	3	2	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	4	2	3	4	4	4	2	4	4	3	98	2.72	4	1067.1	100
1	4	4	3	3	2	4	4	4	4	4	4	0	97	2.69	4	1045.4	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.4	97.97
1	4	4	3	3	2	4	4	4	2	4	4	3	97	2.69	4	1045.4	97.97
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	3	2	3	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	4	4	4	0	96	2.67	4	102	95.96
1	4	4	4	1	3	3	4	4	2	4	4	3	96	2.67	4	102	95.96
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.7	93.97
1	4	4	3	2	2	4	4	4	2	4	3	3	95	2.64	4	1002.78	[illegible]

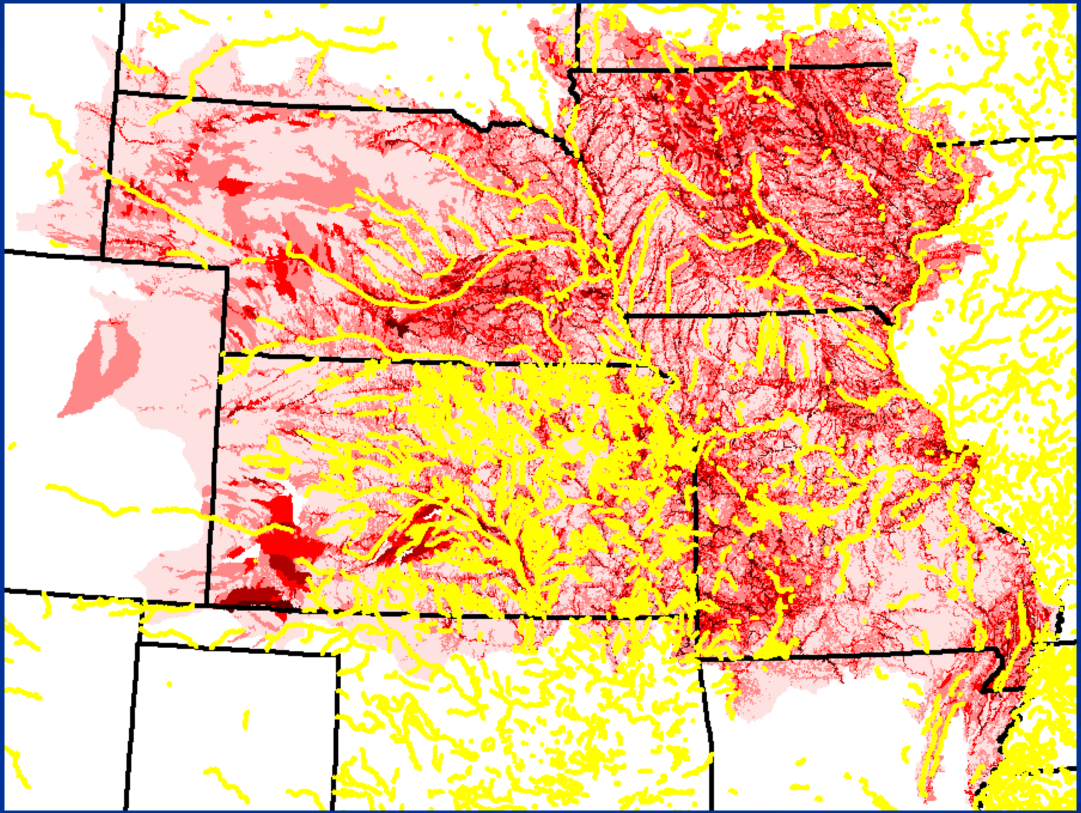


Equal Interval



Natural Breaks

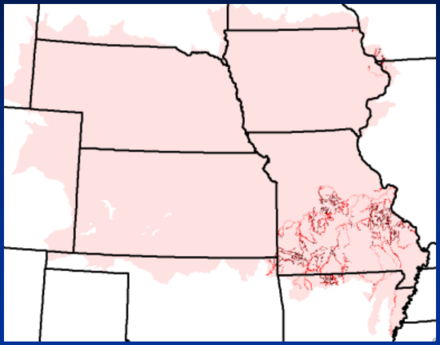
HTI and 303d (2002)



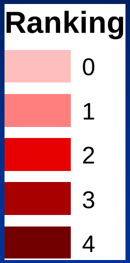
HTI Discussion

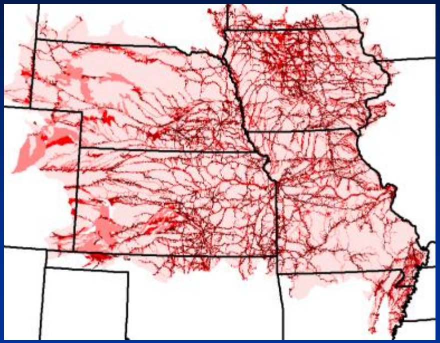
- What should index represent?
  - Degree of threat?
  - Degree of impairment?
  - <u>Probability</u> of impairment?
- Some threats are rare and random (i.e. pipelines)
- Others are persistent (i.e. impervious surface)
- We have these things integrated in the current index
- For example, could have a high number of rare random threats that lead to a high (bad) index, yet stream is high quality

HTI Discussion

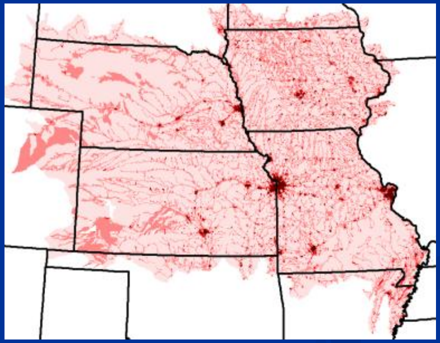


Lead





Rail lines



Impervious

- Can we get closer to measuring degree of impairment?
- To do so we must be able to compare across threats
  - I.e., a “4” for one threat is defined the same as a “4” for another threat
  - Does a single “4” mean the stream should be trashed?

HTI Discussion

Some Observations

- Weighting among threats
  - Urban areas don’t stand out while reservoirs do
- Mainstems
  - Number of threats influences overall HTI
    - Most threats are found somewhere upstream
- The HTI is more influenced by the number of threats rather than individual magnitude
  - One or two <u>very</u> bad threats could result in a low HTI

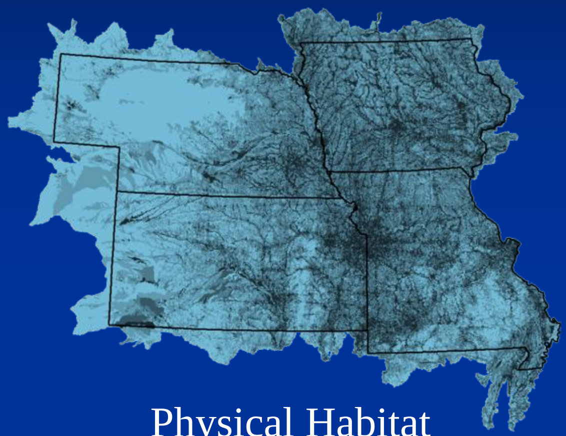
HTI Discussion

- Options for getting closer to measuring impairment
  - Use weighting criteria from "survey of professionals"
  - Make all values relative to highest value
  - More distance restrictions for some threats
  - Quantify threats to more directly relate to stressors
    - For example, quantify area behind impoundments differently

HTI Discussion

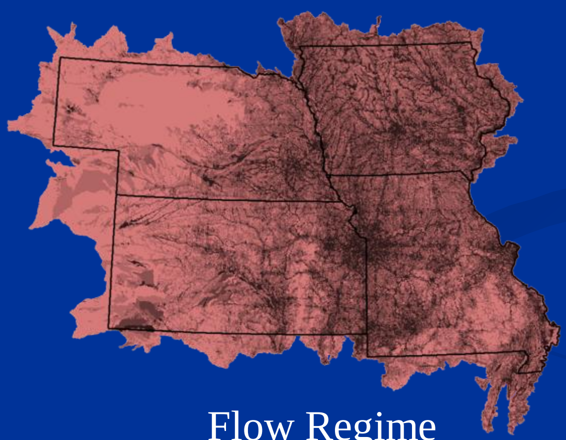
- Bottom line:
  - We would like to get closer to measuring "impairment"
  - Continue investigating ways to create meaningful HTI

Separate Human Threat Index for Components of Ecological Integrity

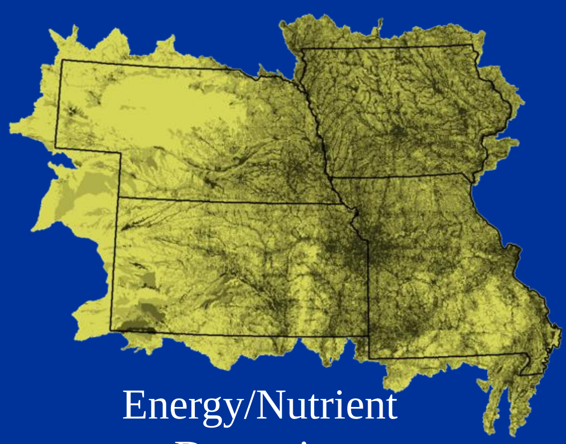


Physical Habitat

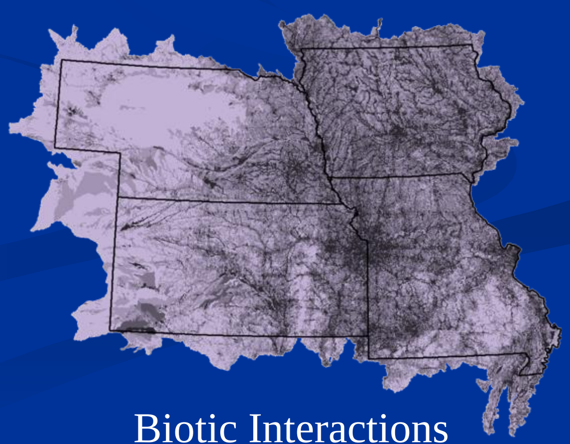
Water Quality



Flow Regime



Energy/Nutrient Dynamics



Biotic Interactions

Developing Separate Indices

	A	B	C	D	E
1	Threats	Physical Habitat			Key
2		Mean	Mode		0 = No Impact
3	Channelization	3.0	3		1 = Low Impact
4	Instream Sand And Gravel Mines	2.9	3		2 = Moderate Impact
5	Major Reservoirs	2.8	3		3 = High Impact
6	Navigation (Channel and Bank Maintenance)				
7	Row Crop Agriculture				
8	Impervious Surface				
9	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)				
10	Introduced Plants				
11	Water Withdrawals				
12	Roads (Paved And Gravel)				
13	Flow Diversions (No Return Flow)				
14	Dispersal Barriers / Low Head Dams				
15	Artificial Drainage (Agricultural Field Drainage)				
16	Military Sites (With Regard to Land Disturbance)				
17	Flow Diversions (With Return Flow)				
18	Road-Stream Crossing (Culverts And Low-Water)				
19	Upland Mining				
20	Ranging Livestock				
21	Storm Water Systems				
22	Bridges				
23	CAFO				
24	Golf Course				
25	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)				

	A	B	C	D	E
1	Threats	Water Quality			Key
2		Mean	Mode		0 = No Impact
3	Waste Water Treatment Facility	2.8	3		1 = Low Impact
4	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)				2 = Moderate Impact
5	CAFO				
6	Row Crop Agriculture				
7	Toxic Releases				
8	Storm Water Systems				
9	Artificial Drainage (Agricultural Field Drainage)				
10	Road Salt Applications				
11	Major Reservoirs				
12	Upland Mining				
13	Impervious Surface				
14	Golf Course				
15	Military Sites (With Regard to Chemical Contamination)				
16	Flow Diversions (With Return Flow)				
17	Rail Yards (Fuel And Coal Dust)				
18	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)				
19	Septic Tanks / Lagoons				
20	Instream Sand And Gravel Mines				
21	Roads (Paved And Gravel)				
22	Oil And Gas Wells				
23	Salt Scars (From Old Abandoned Oil And Gas Wells)				
24	Airports (National and International)				
25	Landfills				

	A	B	C	D	E
1	Threats	Flow Regime			Key
2		Mean	Mode		0 = No Impact
3	Major Reservoirs	2.8	3		1 = Low Impact
4	Flow Diversions (No Return Flow)				
5	Impervious Surface				
6	Channelization				
7	Storm Water Systems				
8	Water Withdrawals				
9	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)				
10	Artificial Drainage (Agricultural Field Drainage)				
11	Navigation (Channel and Bank Maintenance)				
12	Flow Diversions (With Return Flow)				
13	Row Crop Agriculture				
14	Roads (Paved And Gravel)				
15	Waste Water Treatment Facility				
16	Dispersal Barriers / Low Head Dams				
17	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)				
18	Instream Sand And Gravel Mines				
19	Airports (National and International)				
20	Road-Stream Crossing (Culverts And Low-Water)				
21	Upland Mining				
22	Military Sites (With Regard to Land Disturbance)				
23	Bridges				
24	Golf Course				

	A	B	C	D	E
1	Threats	Energy / Nutrient			Key
2		Mean	Mode		0 = No Impact
3	CAFO	2.6	3		1 = Low Impact
4	Waste Water Treatment Facility				
5	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)				
6	Row Crop Agriculture				
7	Major Reservoirs				
8	Artificial Drainage (Agricultural Field Drainage)				
9	Storm Water Systems				
10	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)				
11	Septic Tanks / Lagoons				
12	Golf Course				
13	Introduced Plants				
14	Channelization				
15	Flow Diversions (With Return Flow)				
16	Impervious Surface				
17	Ranging Livestock				
18	Introduced Aquatic Animals				
19	Navigation (Channel and Bank Maintenance)				
20	Pasture And Range Land				
21	Flow Diversions (No Return Flow)				
22	Upland Mining				
23	Dispersal Barriers / Low Head Dams				
24	Roads (Paved And Gravel)				
25	Water Withdrawals				
26	Instream Sand And Gravel Mines				
27	Landfills				

	A	B	C	D	E
1	Threats	Biotic Interactions			Key
2		Mean	Mode		0 = No Impact
3	Introduced Aquatic Animals	2.9	3		1 = Low Impact
4	Major Reservoirs	2.8	3		2 = Moderate Impact
5	Introduced Plants	2.6	3		3 = High Impact
6	Headwater Impoundments (Impoundments on Second-Order and Smaller Streams)	2.4	3		
7	Channelization	2.3	3		
8	Dispersal Barriers / Low Head Dams	2.3	3		
9	Waste Water Treatment Facility	2.2	2,3		
10	Point Source Discharges (NPDES: Municipal, Agricultural, And Industrial)	2.1	3		
11	Row Crop Agriculture	2.0	1,3		
12	Instream Sand And Gravel Mines	2.0	2,3		
13	CAFO	1.9	1		
14	Navigation (Channel and Bank Maintenance)	1.8	1		
15	Toxic Releases	1.8	3		
16	Water Withdrawals	1.8	2		
17	Artificial Drainage (Agricultural Field Drainage)	1.8	1		
18	Road-Stream Crossing (Culverts And Low-Water)	1.8	2		
19	Impervious Surface	1.7	2		
20	Roads (Paved And Gravel)	1.7	2		
21	Flow Diversions (With Return Flow)	1.7	1,2		
22	Storm Water Systems	1.6	2		
23	Flow Diversions (No Return Flow)	1.6	2		
24	Golf Course	1.5	1		
25	Upland Mining	1.4			
26	Ranging Livestock	1.4	1		

Principal Ecological Effects

Point source pollution					
Level of Influence	Physical Habitat	Water Quality	Flow Regime	Energy/Nutrient	Biotic Interactions
Low	X		X		
Medium					
High		X		X	X

Thanks

Environmental Protection Agency

Missouri Department of Natural Resources

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